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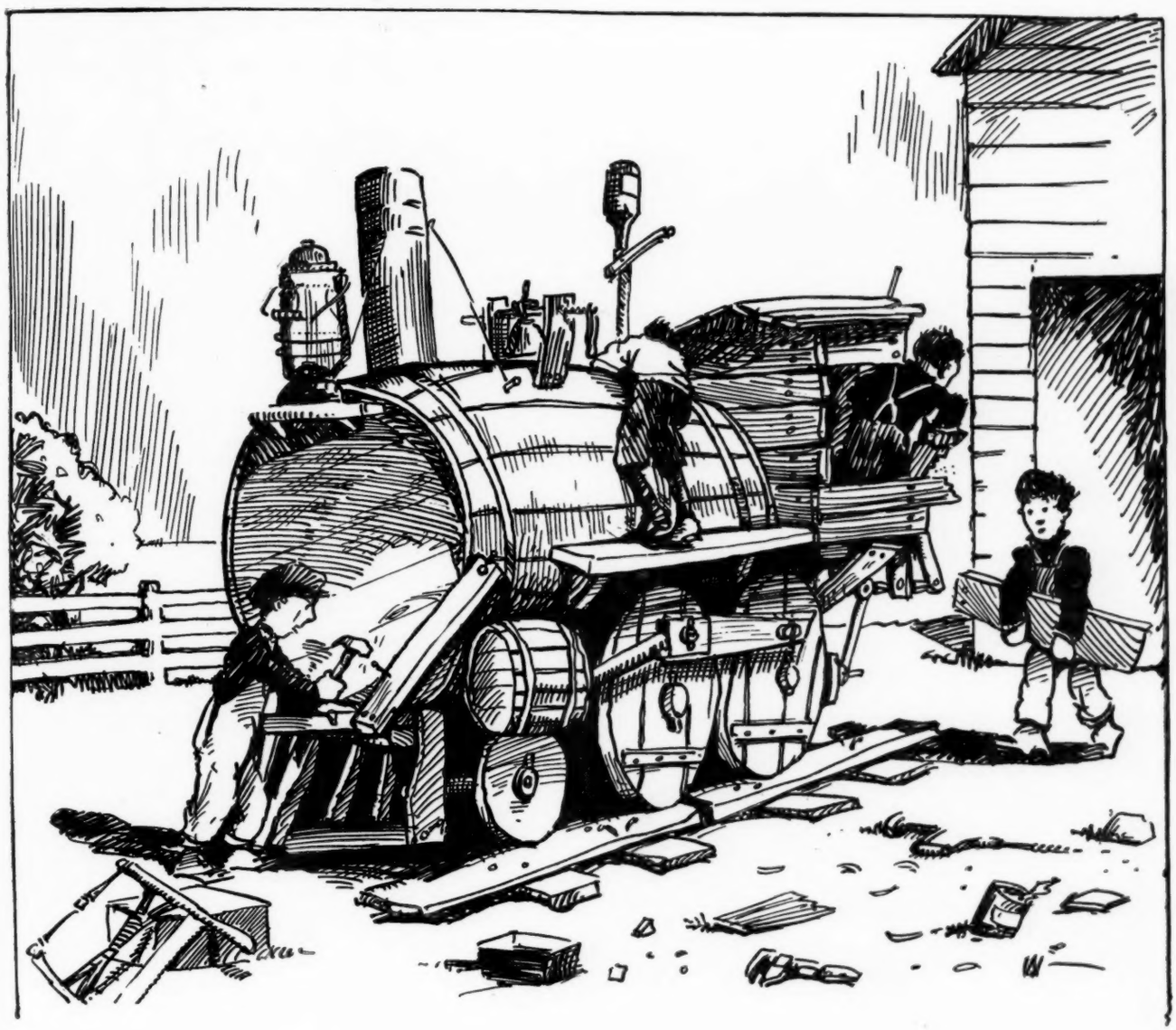

ENGINEERS OF TOMORROW

Drawn by Delevan E. Whaley, Reading, Mich.

Lake Shore Generating Plant

By A. D. Williams

SYNOPSIS—This new turbine plant of the Cleveland Electric Illuminating Co., located on the shore of Lake Erie, has at present a capacity of 61,000 kw. with provision for extension to more than double this amount. The present article deals with the plant in general and will be followed with two other installments treating of special phases of the design and equipment.

Service demands indicated that the Cleveland Electric Illuminating Co., would outgrow its generating capacity and there was no further space available at the original plant on the flats. This and the undesirability of the Cuyahoga River water led the management to seek a site upon the shore of Lake Erie where the water supply would be unlimited and where ample room would be available for future extension. A ten-acre site was secured at the foot of East Seventieth St., running back from the lake about one thousand feet to the main line of the Lake Shore R.R. and the construction of the Lake Shore generating plant was started about three years ago. A portion of the plant has been in operation for about a year, and a fifth unit of 15,000 kw. capacity has just been added. The two 9000-kv.-a. units in this plant were first delivered and placed in operation in the old plant and were afterward removed to the new plant when the installation of the two 14,000-kv.-a. units enabled the Lake Shore plant to carry a large part of the load.

The general plan of the plant, Fig. 2, shows only the north or lake end of the property and the service tracks in the yard which connect with the Lake Shore R.R. The shore of the lake, at this point, forms a steep bluff rising from close to the water's edge to a height of nearly 50 ft. above the water level. The southern portion of the property is level and a portion of it is utilized for coal storage. The generating plant is located at the foot of the bluff on a portion of the site which lays beyond the old shore line of the lake. The building stands upon a concrete mat substructure inclosed in a steel sheet-pile cofferdam, and is built of brick with granolithic trimming. A large proportion of the wall area is of glass, admitting light to all parts of the plant.

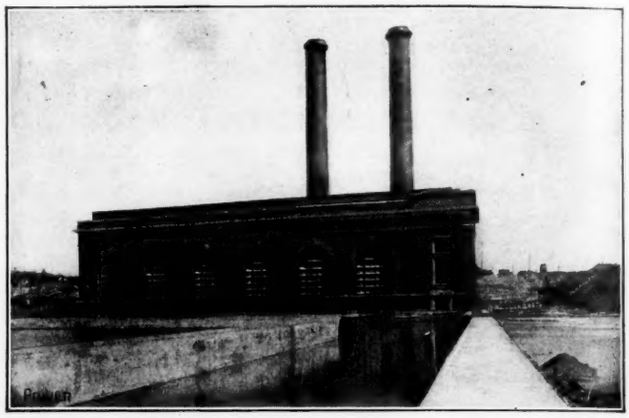

Fig. 1. Power Plant from Intake Canal

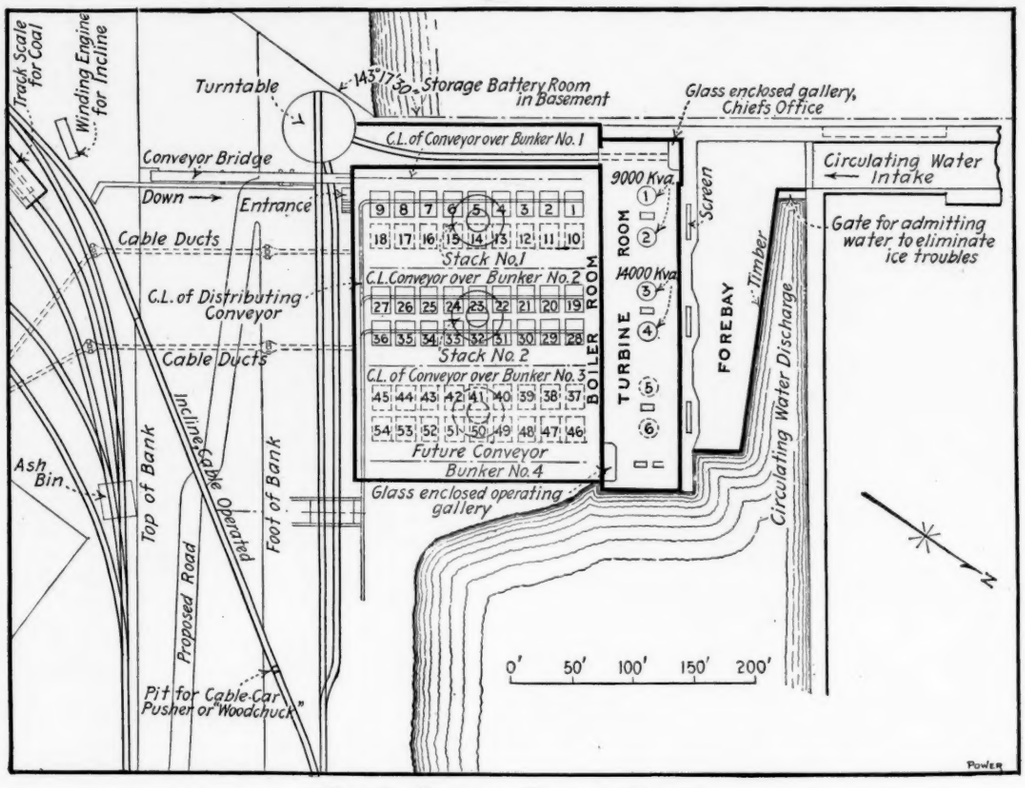

Fig. 2. General Plan of Plant

the wide firing aisles. However, this plant compares very favorably on a space and volume basis with other large plants, as indicated by the following approximate figures:

	Area, Square Feet	Volume, Cubic Feet
Turbine room	28,560	2,252,000
per kilovolt-ampere	0.396	30.43
Boiler room	53,920	3,740,900
per kilovolt-ampere	0.729	50.55
per boiler horsepower	1.664	115.60
Total ground area	82,480	5,992,900
per kilovolt-ampere	1.114	89.88

In general arrangement the Lake Shore plant is somewhat similar to the Fiske Street station in Chicago. The boiler-firing aisles are at right angles with the turbine room. The self-supporting steel stacks with their linings are carried upon the steel framing of the building, and the breechings are placed on the roof of the building over the boilers. The space over the firing aisles is covered by a large hopper-bottom coal bin in a monitor between the stacks.

has been made, the operating gallery, which is now located at the extreme east end, will be in the center.

The level of Lake Erie, at Cleveland, is subject only to small variations, which permits the basement-floor level being placed only one foot above the lake level without incurring any danger from flooding. The turbine floor is 12.5 ft. above the lake and the boiler floor 8.5 ft. higher. This arrangement permits running the boiler-room steam piping below the floor, in the basement, and gives a practically level run to the turbines.

The only machines below the turbine-room floor are the hotwell or wet-vacuum pumps, which have to be placed below the level of the bottom of the condenser, and the surface condensers. The turbine-room floor is slightly below the lowest steam stage of the turbine. All the boiler-feed pumps, high- and low-pressure oil pumps, the dry-vacuum and circulating pumps are in the turbine room.

The generators are of the down-draft ventilated type,

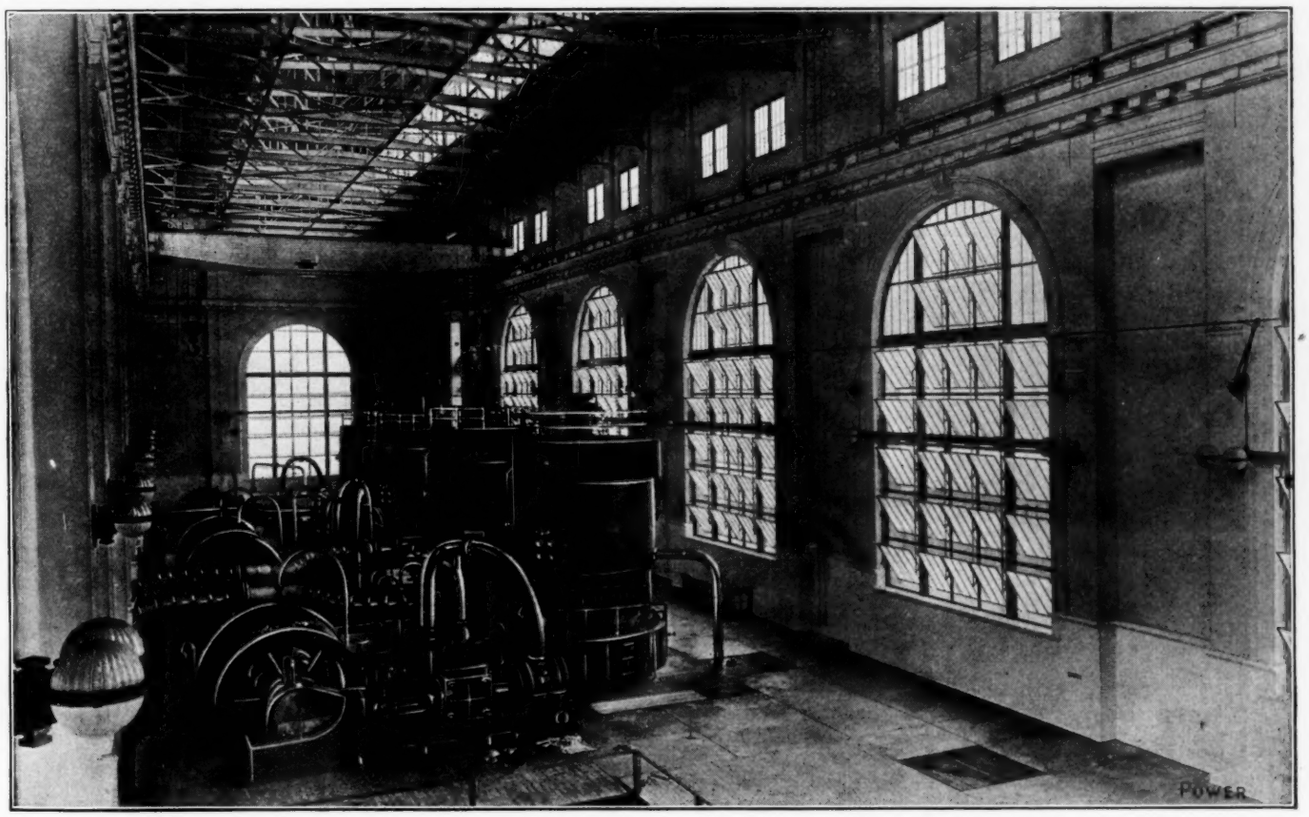

FIG. 3. VIEW OF TURBINE ROOM, SHOWING 14,000-KV.-A. AND 9000-KV.-A. UNITS

The only switching equipment in the power plant is that necessary for the control of the generating equipment, the exciters and the station lighting. The distribution is controlled from a separate switchhouse.

The machinery and boilers are arranged in symmetrical groups, each consisting of two generating units and their auxiliaries in the turbine room and the boilers, stack and bunker supply in the boiler room. Each group is practically an independent unit power plant, three such units forming the equipment, when complete, in the present building, while the space available for extension will permit the installation of four similar unit groups to the east of the present structure. When this extension

the air supply being drawn in from the turbine room through an inlet at one side of the machine just below the top platform, passing down through the air ducts in the machine and being discharged into the room through outlets in the distance piece over the top of the turbine. This method of ventilation avoids the large air ducts leading up to the top of the generator, but the floor framing and plates are so arranged that air may be drawn from outside of the building should this become necessary. The approximate air circulation through the turbines is 40,000 cu.ft. per min. for the 9000-kv.-a. units and 50,000 cu.ft. per min. for the 14,000-kv.-a. units. These machines are guaranteed to operate at 85 per cent. power

EQUIPMENT OF LAKE SHORE GENERATING PLANT

	Equipment	Type	Service	Volts	Amperes	R.p.m.	Size	Number Stages	Capacity	Temperature and Pressure	Maker and remarks
2	A. C. Generators....	3-phase 60-cy vert.	Main units 1 & 2	11,431	455	720	....	...	9,000 kv.a	....	G. E. Co.
2	A. C. Generators....	3-phase 60-cy vert.	Main units 3 & 4	11,431	706	720	....	...	14,000 kv.a	.....	G. E. Co.
1	A. C. Generator....	3-phase 60-cy vert.	Main unit 5	11,431	756	720	....	...	15,000 kv.a	.....	G. E. Co.
2	Turbines.....	Curtis vert.	Main units 1 & 2	....	....	720	....	5	....	215 lb. 125° F. Superheat	G. E. Co.
2	Turbines.....	Curtis vert.	Main units 3 & 4	....	....	720	....	5	....	215 lb. 125° F. Superheat	G. E. Co.
1	Turbine.....	Curtis vert.	Main unit 5	....	....	720	....	5	....	125° F. Superheat	G. E. Co.
2	Surface condensers..	Base type two-pass	Units 1 & 2	....	....	.....	16,000 sq.ft.	..	140,000 lb. steam per hr.	28 in. vac. 70° F. circ. water	Wheeler Cond. & Eng. Co.
2	Surface condensers..	Base type two-pass	Units 3 & 4	....	....	.....	25,000 sq.ft.	..	224,000 lb. steam per hr.	28.6 in. vac. 60° F. circ. water	Alberger Cond. Co.
1	Surface condenser...	Base type two-pass	Unit 5	....	....	.....	....	..	....	28.6 in. vac. 60° F. circ. water	Alberger Cond. Co.
2	Dry vacuum pumps.	Corliss	Units 1 & 2	....	....	75–110	18 & 30x18	1	....	215 lb.	Flash port in air cylinder Wheeler Cond. & Eng. Co. C.&G. Cooper Co., steam end.
2	Circulating pumps..	Centrifugal double suction	Units 1 & 2	....	....	75–110	30 in.	1	24,000 gal.	.....	Wheeler Cond. & Eng. Co.
2	Dry vacuum pumps.	Corliss	Units 3 & 4	....	....	100–150	20 & 34x24	1	....	215 lb.	Flash port in air cylinder. Alberger Cond. Co.
1	Dry vacuum pump..	Corliss	Unit 5	....	....	.....	....	...	....	.....	Alberger Cond. Co.
2	Circulating pumps..	Centrifugal double suction	Units 3 & 4	....	....	100–150	36 in.	1	30,000 bal.	.....	Alberger Cond. Co.
1	Circulating pump...	"	Unit 5	....	....	.....	....	...	....	.....	Alberger Cond. Co.
2	Hot well pumps.....	Centrifugal	Units 1 & 2	....	....	2000	4 in.	1	300 gal.	.....	Wheeler Cond. & Eng. Co.
2	Turbines.....		Units 1 & 2	....	....	2000	....	1	10 hp.	.....	Terry Turbine Co.
3	Hot well pumps.....	Centrifugal	Units 3, 4 & 5	....	....	2220	6-in. suction 5 in discharge	1	675 gal.	.....	Alberger Cond. Co.
3	Turbines.....		Units 3, 4 & 5	....	....	2220	....	1	....	.....	Terry Turbine Co.
2	Free exhaust valves..		Units 1 & 2	....	....	.....	30 in.	...	....	.....	Crane Co.
3	Free exhaust valves..		Units 3, 4 & 5	....	....	.....	36 in.	...	....	.....	Crane Co.
6	Pumps.....	Centrifugal	Boiler feed	....	....	3–2000 3–1700	6 in.	4	625 gal.	.....	Suction head 5 ft. Discharge head 320 ft. Platt Iron Works Co.
3	Turbines.....		Boiler feed	....	....	2000	....	1	180 hp.	175 lb.	2 in. back pressure. Terry Turbine Co.
3	Turbines.....		Boiler feed	....	....	1700	....	1	150 hp.	175 lb.	Terry Turbine Co.
8	Pumps.....	Duplex plunger	Step bearing	....	....	.....	12x2½x12	...	....	.....	Dean Bros. Outside packed.
5	Accumulators.....	Vertical	Step bearing	....	....	.....	12 in.x13 ft.	...	850 lb.	.....	R. D. Wood & Co.
8	Pumps.....	Duplex	Lubrication	....	....	.....	6x4x6	...	....	.....	Dean Bros.
4	Pumps.....	Vertical	Oil returns	....	....	.....	....	...	....	.....	Dean Bros.
1	D. C. generator.....	Interpole	Exciter	140	900	2500	....	...	125 kw.	.....	G. E. Co.
1	Turbine.....	Curtis horizontal	Exciter	....	....	2500	....	...	....	215 lb.	G. E. Co.
2	D. C. generators....	Interpole	Exciter	125	1600	500–514	....	...	200 kw.	.....	G. E. Co.
2	Motors.....	3-phase	Exciter	2200	72	500–514	....	...	300 hp.	.....	G. E. Co.
1	Storage battery.....		Exciter	140	....	.....	60 cells	...	....	.....	Electric Storage Battery Co. 60 cells and 20 end cells
1	D. C. generator.....	Interpole	Booster for battery	80–230	300	500	....	...	67.5 kw.	.....	W. E. & M. Co.
1	Motor.....	3-phase	Booster set	2200	....	500	....	...	100 hp.	.....	W. E. & M. Co.
1	D. C. generator.....	Interpole	Ashes	250	140	850	....	...	35 kw.	.....	Lincoln Electric Co.
1	Motor.....	3-phase	Ashes	230	126	850	....	...	60 hp.	.....	Lincoln Electric Co.
1	Crane.....	Overhead traveler	Turbine room	....	....	.....	....	...	....	.....	Cleveland Crane & Eng. Co.
1	Pump.....	Volute double suction	Sump	....	....	.....	....	1	150 gal.	.....	10-ft. head. Jeansville Iron Works.
1	Motor.....	3-phase	Sump pump	220	35.5	1800	....	...	15 hp.	.....	G. E. Co.
1	Air compressor.....			....	....	.....	10x10	...	....	.....	Clayton Air Compressor Co. Morse chain drive.
1	Motor.....	3-phase	Air compressor	220	....	900	....	...	25 hp.	.....	Crocker-Wheeler Elec. Co.
5	Heaters.....	Closed, vertical	Boiler feed	....	....	.....	....	...	....	.....	Wheeler Cond. & Eng. Co. Alberger Cond. Co.
27	Boilers.....	Stirling	Main units	....	....	.....	6000 sq.ft.	...	600 hp.	215 lb.	B. & W. Co.
27	Superheaters.....	Foster	Boilers	....	....	.....	800 sq.ft.	...	15,250 lb. per hr.	100° F.	Power Specialty Co.
27	Stokers.....	Chain grate	Boilers	....	....	.....	10x11 110 sq.ft	...	20-40 lb. per sq.ft per hr.	.....	2 to 10 in. travel per min. 2 to 4 in. draught. Green Engineering Co.
9	Engines.....	Slide valve	Stokers	....	....	.....		...	....	.....	
2	Chimneys.....	Steel lined	Boilers	....	....	.....	18.5x216 ft.	...	....	.....	E. H. Waches, (Chicago)
27	Water columns.....		Boilers	....	....	.....	....	...	....	.....	246 ft. above grates. Jas. McNeil Bros. Co.
27	Draught regulators..		Boilers	....	....	.....	....	...	....	.....	D. T. Williams Valve Co.
27	Scales.....		Coal hoppers	....	....	.....	6 ton	...	....	.....	Howe Scale Co.
	Valves.....		Steel body	....	....	.....	....	...	....	.....	Crane Co. & Nelson Valve Co.
	Piping.....		Soft steel	....	....	.....	....	...	....	.....	Pittsburgh Piping & Equip. Co.
1	Turntable.....		Switching	....	....	.....	....	...	....	.....	Detroit Air Motor Tractor.
3	Conveyors.....	30-in. belt	Bunkers	....	....	.....	200 ft. long	..	300 tons per hr., 400 ft. per min.	.....	C. O. Bartlett & Snow.
3	Motors.....	3-phase	Conveyor	220	....	.....	....	...	25 hp.	.....	G. E. Co.
1	Conveyor.....	30-in. belt	Distributing	....	....	.....	250 ft. long	..	300 tons 400 ft. per min.	.....	C. O. Bartlett & Snow
1	Motor.....	3-phase	Conveyor	220	....	.....	....	...	....	.....	G. E. Co.
1	Conveyor.....	30-in. belt	Incline	....	....	.....	302 ft. long	...	400 ft. per min.	.....	C. O. Bartlett & Snow
1	Motor.....		Conveyor	220	....	.....	....	...	50 hp.	.....	G. E. Co.
2	Crushers.....	4-roll		....	....	.....	24x26 in.	...	75 ton per hr.	.....	C. O. Bartlett & Snow
2	Motors.....	3-phase	Crushers	220	....	865	....	...	75 hp.	.....	G. E. Co.
2	Feeders.....	Double-plunger	Crushers	....	....	.....	....	...	....	.....	C. O. Bartlett & Snow
2	Motors.....	3-phase	Feeders	220	....	865	....	...	15 hp.	.....	G. E. Co.
1	Track scale.....		Track hopper	....	....	.....	....	...	150 ton	.....	Standard Scale & Supply Co.
1	Crane.....	Steam locomotive	Yard	....	....	.....	....	...	....	.....	Browning Eng. Co.
1	Bench board.....		Main units	....	....	.....	....	...	....	.....	Walker Elec. Co.
1	Switchboard.....		Exciter	....	....	.....	....	...	....	.....	Walker Elec. Co.

factor with a temperature rise of less than 50 deg. C. The full-load excitation current is as follows:

	9000-kv.a. Units	14,000-kv.a. Units
Exciting current, unity power factor	355 amp.	375 amp.
	90 volts	85 volts
Exciting current, 80 per. cent power factor	435 amp.	460 amp.
	110 volts	105 volts

Direct current for this purpose is supplied by two motor-generator sets and one turbo-exciter unit. A storage battery is provided to supply current should the generators fail or be shut down for any reason. This battery normally is floated on the exciter busbars. An independent motor-generator set is installed for charging the battery and the possibility of any interruption in the field excitation while the battery is being charged is taken care of by an automatic switch which disconnects the charging set and throws the battery on the busbars if the current supply fails. Reverse-current relays are connected in the exciter-generator leads and operate the circuit-breakers connecting them to the busbars. The lighting circuits of the plant are sectionalized so that a sufficient number of lamps to partially light all parts of the plant can be connected with the exciter battery in case the other sources of energy fail.

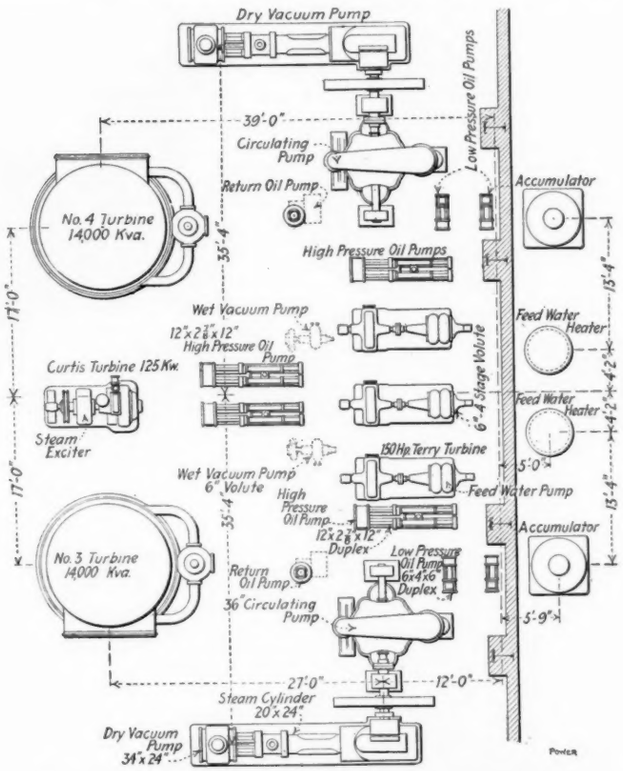

FIG. 4. ONE TURBINE GROUP WITH AUXILIARIES

It has been found undesirable, if not practically impossible, to hold the convention of the National Electric Light Association later than June, on account of certain constitutional provisions. It has been decided, therefore, to hold the 1915 N. E. L. A. convention during the week of June 14, at San Francisco.

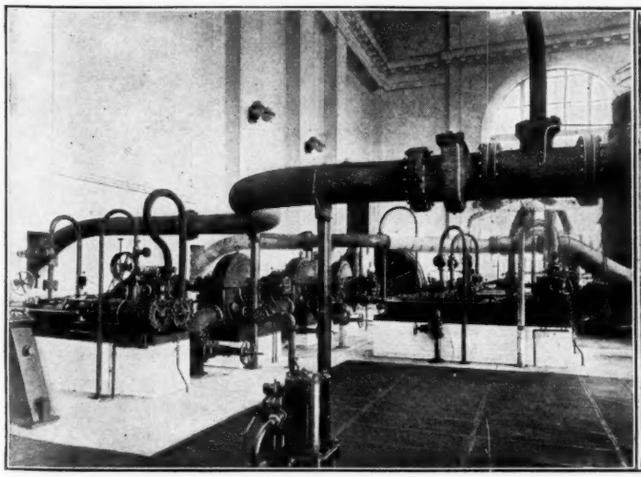

FIG. 5. SHOWING AUXILIARIES

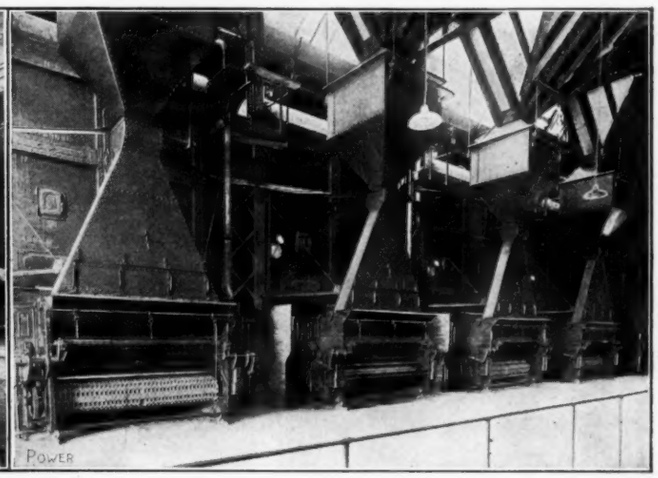

FIG. 6. WELL LIGHTED FIRING AISLE

One of the peculiar features of this plant is the use of an inclined plane and a turntable to facilitate the installation of machinery. The bluff at this point would have given a 50 per cent. grade about 100 ft. long if the switch track had been run directly into the building. A slope as steep as this would be extremely difficult to operate with heavy carloads and a runaway would have seriously damaged the structure. In order to minimize the risk of operation and the possibility of damage the cable-operated incline was run diagonally down the bank, reducing the grade to about 10 per cent., and the cars are switched back along the shore side of the building where the boiler-room floor comes about level with the platform of the car. The turntable became necessary with this trackage arrangement in order to permit loaded cars being run into the turbine room where the heavy parts can be unloaded by means of the crane.

San Francisco Conventions in 1915

Arrangements are being made for holding the annual conventions of engineering societies in San Francisco during the exposition period in 1915. Among these are the conventions of the International Electrotechnical Commission, during the week of Sept. 6; International Electrical Congress, week of Sept. 13; General Engineering Congress, week of Sept. 20; and International Gas Congress, week of Sept. 27. It is probable that the American Electric Railway Association will hold its convention during the week of Oct. 4.

Jacketing Applied to Steam Cylinders

SYNOPSIS—As a number of inquiries have been received relative to steam jacketing, we believe the following extract from an article by Dr. Hubert Hanszel, which appeared some time ago in Zeitschrift des Vereines Deutscher Ingenieure, will be of interest. Among other things, are shown the effects of superheated steam with and without jacketing, the effects of partial jacketing and the economy of jacketing with simple, compound- and triple-expansion engines.

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The test was made a few years ago on a 150-hp. Görlitz triple-expansion engine at the Technical University of Berlin for the purpose of determining the effect of steam jacketing and other important heat phenomena in the working cycle of the steam engine.

In this case it was particularly important to accurately determine the condensate in the jackets and receivers. The usual arrangement with traps, the discharge from

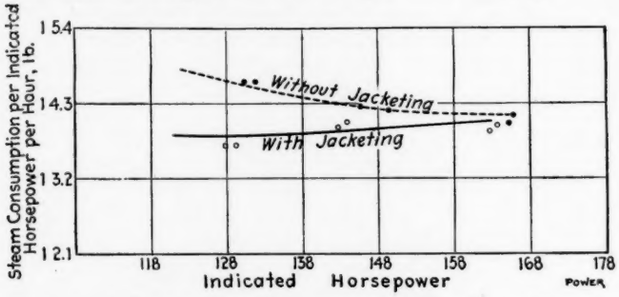


FIG. 1. HOURLY CONSUMPTION OF SATURATED STEAM

which is led off through cooling coils, usually gives too high a value; hence the condensation was collected in closed tanks with water columns and discharged through cooling coils under its own pressure. For the second receiver, in which generally a partial vacuum prevailed, two such tanks were used consecutively.

To prove the correctness of the tests, complete heat balances were established. The good agreement of the losses due to radiation, flow and conduction which appeared as the difference between the measured heat volume supplied and that credited, is a proof of the accuracy of the tests.

It was important to determine the apportionment of these external losses among the individual cylinders because there is thus presented the possibility of knowing the intermediate condition of the steam. To that end a radiation test was made with the engine at rest and the jacket heated. As the greater part of the surfaces, responsible for these losses, were thus under the same temperature as in regular operation an approximation of actual conditions was realized. As a result there appeared as hourly heat losses in the high-, intermediate- and low-pressure cylinders, respectively, 31,744, 30,950 and 32,567 B.t.u.; the last including the exhaust pipe.

In this particular case, with jacketing the quality of the steam in the receivers never went below 0.95, while without jacketing it fell to 0.91. Draining the receivers raised this about 0.01 to 0.05, but there remained constantly 1 to 5 per cent. water in the steam. Still the engine ran uninterruptedly even with the high water content of 9 per cent. However, the best of drainage should be sought as wet steam exercises an unfavorable influence in loss of heat in the cylinders. So long as the walls are covered with deposited moisture, heat exchange is active, as large volumes of heat are withdrawn from the walls for its reëvaporation.

For the series of tests made with saturated steam, Fig. 1 shows the steam consumption referred to the indicated load. It appears from this that at the highest duty there was practically no difference in the steam consumption between jacketing and no jacketing, while with decreasing load and without the jacket the consumption increased as opposed to its decrease with the jacket.

CYLINDER EFFICIENCY*

Although the effects of clearance, wire-drawing at admission and at release, pressure drop during passage of the steam from cylinder to cylinder and possible leakages are all functions of cylinder efficiency, the heat exchange with the cylinder walls may be accepted as the largest factor, because by comparison the other losses, in the same engine and within not too wide limits, can be assumed as constant. The tests confirmed this assumption as the cylinder efficiency is in intimate agreement with the quality of the steam at the beginning of expansion.

The weight and quality of the working steam being given for all the intermediate stages the individual cyl-

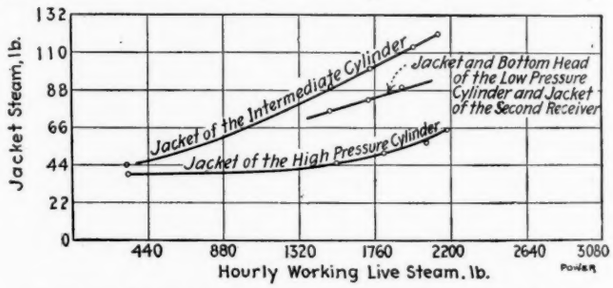


FIG. 2. JACKET STEAM DEPENDENT ON WORKING LIVE STEAM

inder efficiencies can be determined and it is thus possible to judge of the effect of the jacket heating on each cylinder.

In combination with wet steam, the effect of pressure drop on the heat-transferring side of the cylinder walls is further proved by the noticeable showing in Fig. 2, that with increasing cutoff the jacket condensate increases, notwithstanding the higher average wall temperature. This was the case for all three cylinders, as is evident from the curves plotted to show the jacket consumption as dependent on the weight of the working steam. It would seem that in consequence of the higher temperature in the interior of the cylinder the quantity of jacket steam should decrease with increasing cutoff, but the reverse appears to be the case.

PARTIAL JACKETING

Based on the separate cylinder efficiencies it can generally be determined what effect partial jacketing has on

*The term "Cylinder Efficiency" is used here as the equivalent of the German "Gütegrad," which expresses the fractional value:

$$\frac{\text{Steam consumption in a "no-loss" engine with incomplete expansion}}{\text{Steam consumption in the actual engine}}$$

the steam consumption. With jacketing for the high-pressure cylinder an increased duty of about 3 per cent. of the total duty can be expected from a 2.5 per cent. greater expenditure of jacket steam. If the jacket heating be omitted for the high-pressure cylinder alone the steam consumption would not be materially changed.

For the intermediate cylinder an expenditure for jacket steam of about 5 per cent. of the total steam improves the cylinder efficiency about 11 per cent., or referred to the complete engine about 5 per cent., and thus here too the steam consumption would not be particularly influenced by the omission of jacketing. On the contrary, in the low-pressure cylinder with the jacket steam representing only 2.5 per cent. of the total steam the cylinder efficiency is improved about 20 per cent. and the engine duty is increased approximately 8 per cent. Thus, doubtless, only the omission of jacketing from the low-pressure cylinder materially raises the steam consumption.

In short, from the foregoing the influence of the jacket on the three cylinders considered separately is as follows: The heating of the high-pressure cylinder has little effect, but the heat operates for good in the succeeding cylinders. Jacketing of the intermediate cylinder is more effective. Both the high and the intermediate jackets are of immaterial influence on the total efficiency, whereas heating of the low-pressure cylinder raises its efficiency to such an extent that, nothwithstanding the non-utilization in the higher stages of expansion, the total efficiency becomes greater.

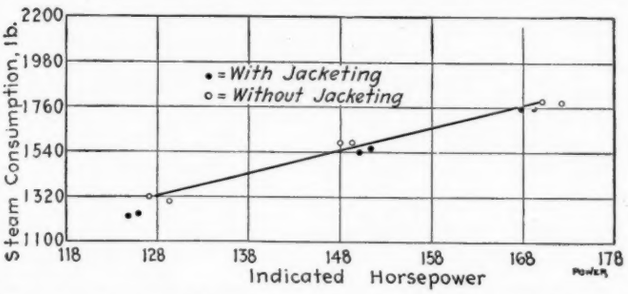


FIG. 3. HOURLY CONSUMPTION OF SUPERHEATED STEAM

To determine by direct measurement the effect of partial jacketing on the steam-consumption, tests were made at the high load (170 hp.), which confirmed the foregoing statements.

SUPERHEATED STEAM WITH AND WITHOUT JACKETING

Two series of comparative tests were made with superheated steam with and without jacket heating and at the same loads as with saturated steam, namely, 130, 150 and 170 hp. Within the limits of the investigation the hourly steam consumption with and without jacketing was the same (see Fig. 3). This is not surprising as here, in the high-pressure cylinder, the influence of the jacket on the initial loss disappears through the effect of superheating. Jacket heating of the high-pressure cylinder was applied for the higher loads, but it did not suffice to even cover the exterior heat losses by radiation, etc. For the smaller loads it was not used. Thus above all, in addition to the effect of jacketing the intermediate- and low-pressure cylinders, the weight at cutoff in the high-pressure cylinder has bearing on the steam consumption.

The dependence of the efficiency of the high-pressure cylinder on the cutoff is clearly shown by Fig. 4. For the same total efficiency the utilization in this cylinder is poorer with the jacket in use.

The improvement of cylinder efficiency through superheating is considerable, as is to be expected. (75 to 90 per cent. for superheated steam as compared with 68 per cent. for saturated.) The improvement in efficiency of the intermediate- and low-pressure cylinders through jacketing is somewhat less than when operating with saturated steam, as the steam is drier unjacketed than when using saturated steam.

Throughout the entire extent of the investigation the improvement in total efficiency through jacketing was offset by the non-utilization of the jacket heat in the higher stages of expansion and the poorer efficiency in the high-pressure cylinder.

A complete thermodynamic analysis of the three comparative tests was carried out for the purpose of more closely following the heat movement in the cylinder walls.

As already mentioned the amount of initial loss at the beginning of expansion, is to be considered as an indication of the cylinder utilization of the steam. When operating the engine with jacket heating, of the 375.37 B.t.u. contained in the working steam in the high-pressuer cylinder during one revolution, 54.76 B.t.u. were absorbed by the walls up to the beginning of the expansion. Without jacketing, of the 402.35 B.t.u. so contained, 47.22 were transferred to the walls. Using superheated steam, out of a heat content as before of 342.44 B.t.u., only 19.84 were absorbed by the walls in spite of the greater temperature differences; showing the evident superiority of superheating as a means for lowering the initial loss.

A large part of this wall heat returns to the steam during expansion. With jacketing of the 54.86 B.t.u. absorbed 44.05 were returned; and without jacketing of the 47.22 B.t.u. absorbed 38.38 were returned. Still of this heat recovery only a very small part was converted into work in the same cylinder; about 7.9 B.t.u.

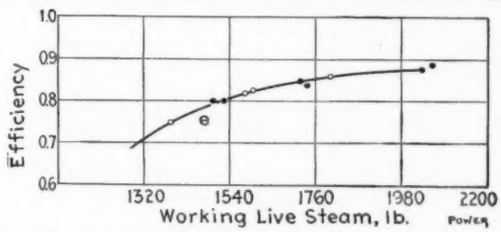


FIG. 4. HIGH-PRESSURE CYLINDER EFFICIENCY REFERRED TO TOTAL STEAM—FOR SUPERHEATED STEAM

A comparison of heat-flow diagrams for the low-pressure cylinder showed a still greater difference in the heat loss at admission; 92.05 B.t.u. without jacket heating and 45.23 with. Of the 92.05 B.t.u. absorbed by the walls, 57.54 (62.5 per cent.) were returned to the steam; only 35.5 B.t.u. of which were returned to the steam during expansion and of that only an inappreciably small part (0.12 B.t.u.) was available for work.

The tests with superheated steam afforded opportunity for observing the heat loss in the piping. The temperature of the steam was taken immediately at the separately fired superheater and close to the engine. Between these points there was about 33 ft. of piping with different bends, numerous flanges and two valves, and with the exception of the flanges it was well covered with non-conducting material.

With saturated steam the heat loss was determined by separating the entrained water, but at higher velocity the separation was less. Again, with superheated steam difficulties were encountered in measuring the temperature of the steam to determine its quality as the temperature fluctuated strongly, the thermometer wells led off considerable heat and above all because superheated steam in the piping does not represent a homogeneous structure. In straight lines of piping there should be conceived existing longitudinal strata which in consequence of pipe friction have different velocities and, resultant from the outward heat flow, different temperatures. If a sudden change of direction or cross-section occurs, these strata mingle. Thus temperature measurement in a superheated steam line is of value in determining its condition only when through a whirling action of the steam at the place of measurement stratification does not exist.

The results of these tests showed that the temperature at the walls of the pipe was from 25 to 34 deg. lower than at the middle, but that moving toward the latter it rises rapidly so that the increase in temperature from a point about ½ in. from the wall to the middle of the pipe is less than 1.8 deg. The actual average temperature of the fully mixed steam would in this case lie about 3.6 deg. below the measured temperature at the middle of the pipe. In this instance the point of measurement lay just behind a bend, so that in longer straight parts of the piping a greater inequality of the steam could be expected.

Other Tests

A comprehensive view of various tests made of single-cylinder noncondensing engines using saturated steam shows an important saving of steam through jacketing. Even with large engines with an hourly steam consumption of 3000 to 6000 lb. the saving still amounts to 10 per cent.; with the smaller ones it reaches 25 per cent. or more. With single-cylinder condensing engines using saturated steam the saving within equal limits is about the same as with noncondensing engines. With very large engines having a steam consumption of over 8000 lb. per hr. the saving is unimportant; a test made while consuming 9900 lb. of steam per hour showing a saving of hardly 3 per cent.

Compound-condensing engines operated by saturated steam show a decrease in steam consumption through jacketing of 30 per cent. in smaller sizes, falling to 5 per cent. for large engines.

Compound engines with superheated steam show an improvement through jacket heating of at most 15 per cent. and from that down to none. Here it seems that for engines with a total steam consumption of 6600 lb. per hr., or 11 lb. per hp.-hr, and a heat consumption per horsepower-hour of 13,888 B.t.u. the limit of effectiveness of the jacket is reached. Again, with the smaller triple-expansion engines the saving varies between 15 per cent. and nothing, and the limit of usefulness of the jacket lies at hourly steam and heat consumptions per horsepower of, respectively, 12 lb. and 14,285 B.t.u.

Summary and Deductions

Receiver heating by means of the usual simple jacket is of no advantage; only an appreciable superheating of the steam in the receiver can be productive of improvement in the utilization of the steam, and only then to a small per cent.

Receiver drainage should be as complete as possible.

Within narrow limits cylinder jacketing results in an improved steam consumption under the following general considerations: With saturated steam the static system is to be preferred to the fluent, more so for head than for jacket heating, of which ordinarily both should be used. The saving in steam through jacketing is intimately dependent on the economy of the engine in steam consumption; the poorer this is the greater the saving. It is also greater for single-cylinder engines, for a lesser number of revolutions, and for small engines using saturated steam. For more economical engines, such as the triple-expansion type, and with superheated steam, the saving is unimportant, and is principally at the shorter cutoffs.

The limit of economy for jacket heating lies approximately at a heat consumption of 13,888 to 15,872 B.t.u. per hp.-hr.

To jacket a cylinder running on superheated steam of the usual temperature of 527 deg. or more is mostly superfluous. Moreover, a good jacket effect on superheated steam is attainable only through exceptional constructive conditions.

In the question of the economy of jacket heating the steam plant must be considered in its entirety. In plants where the water of condensation is forced back into the boilers while the exhaust steam remains unutilized, jacketing is more economical. If the exhaust is used, as for heating purposes, etc., it is often better to send all the steam through the cylinders, particularly if there is no means for utilization of the condensate.

Operated with saturated steam and at light loads it is true that the triple-expansion engine investigated showed through jacketing an improvement in steam consumption of about 5.5 per cent.; still with increasing duty this improvement diminished. At small overloads the consumption was practically the same with and without jacketing; nor was there any difference with superheated steam at normal load. Of the individual cylinder heatings, that of the low-pressure cylinder was shown to be effective.

The auxiliary test showed that with reference to friction a maintained constancy of effect was not reached before two or more hours of operation, while comparatively the temperature of the iron masses in contact with the steam was rapidly reached. Preheating or "warming up" of engines unprovided with jackets is satisfactorily accomplished by direct admission of steam to the cylinders, and by this means the inner temperatures rise materially quicker than by heating through the jackets. The fixed steam consumption per horsepower-hour appeared after three hours and during the first hour was only about 6 per cent. above normal.

❖

In a certain Eastern school building complaint was made about the short life of the incandescent lamps furnished, many globes being found with their filaments broken and twisted to the sides of the glass. The lamps themselves, when tested in regular life racks, showed good average performances, so that a service test was finally determined upon for the purpose of studying the lamps under actual working conditions.

In twenty-six days, according to the New York Electrical Testing Laboratories, fifty-six lamps, or 29 per cent. of the total, burned out. Thirteen new lamps were then put in one of the fixtures, and after being dusted in the regular manner with a feather duster, current was turned on and four of the lamps immediately burned out. Wiping with a slightly dampened cloth was substituted for the cleaning with the feather duster, and the abnormal breakage at once ceased, indicating that the trouble was caused by the action of static charges of electricity produced by the feathers rubbing on the glass of the lamp.

The Prat System of Induced Draft

SYNOPSIS—The Prat system is distinguished from the ordinary suction system in that the blower does not handle the whole volume of gas but supplements the natural draft by induction. By this means a smaller fan is possible and better regulation is claimed.

The following is an extract translated from a pamphlet by Louis Prat, of Paris, describing the Prat system of induced draft. Although, as yet, practically unknown in this country, this system has been used extensively abroad. However, a similar system is now being put forward by an American firm—Schutte & Koerting Co., of Philadelphia. The pamphlet says in part:

The only logical solution of the mechanical draft problem is the fan blower, of which there are different methods of application, as forced, suction, and the Prat or induced system. It is wrong, as is sometimes done, to apply the term "induced" to the suction system. The Prat is the only one which acts by induction; the blower not participating directly in the suction produced.

In this method the pressure varies from point to point and where it equals that of the atmosphere it is customary to refer to it as "zero." For moderate operation the line *A* (Fig. 1) shows the pressure at the ashpit and the sub-atmospheric, or negative, pressure at the damper. If the service be increased the discharge of the gases will be in obedience to the quadratic law and the pressures will mount considerably as indicated by the line *B*. The capacity of the chimney for negative pressure is the invariable maximum represented by the point *I*, and if, notwithstanding this, it be desired to discharge the gases at that negative pressure it will be necessary to considerably augment the positive pressure in the ashpit. This is indicated by the line *C*. But then the zero pressure will be displaced from *N* to *N'* and the furnace will be under the pressure *J*; resulting in a revulsion of smoke and, if the furnace door be opened without shutting off the air, an outburst of flame will result.

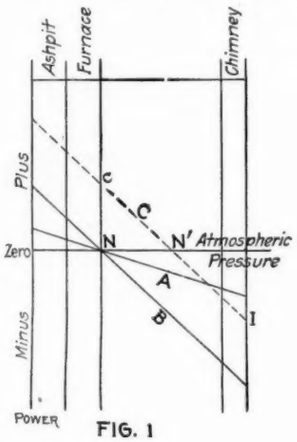


FIG. 1

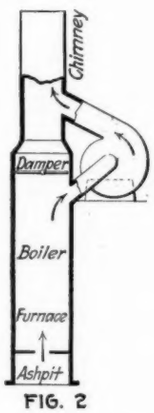


FIG. 2

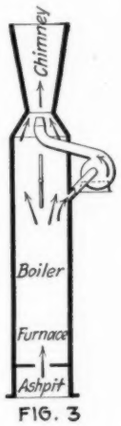


FIG. 3

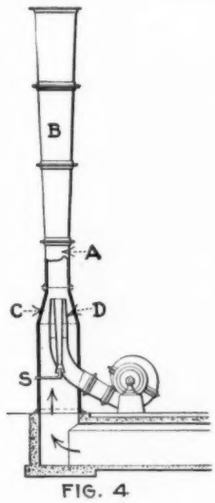


FIG. 4

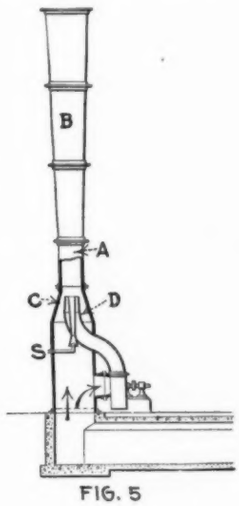


FIG. 5

The only mode of artificial draft suited to yield entire satisfaction for all conditions of combustion, no matter how forced, is that based on suction and with which method there is practically no limit to the negative pressure furnished at the chimney. But a distinction should be made here between the ordinary suction draft and the Prat system of induced draft.

With the direct suction draft of Fig. 2, the damper should always be closed, otherwise the fan would operate without useful effect. It is thus necessary to pass the total volume of the gases through the fan, hence an enormous bulk for the latter. If, to cut down the cost, the size of the fan be restricted, which is compulsory in practice, the resistance is very much increased. Not only is the benefit of natural draft thus lost but the total resistance of the circuit is increased and the work of the fan is greatly enhanced; first, because of this added resistance and second, because of its operating through too large an orifice.

The Prat induced draft system differs fundamentally from the foregoing suction system. The damper, no longer necessary, is always open; the chimney is freely divergent and, the resistance being but little affected, a full utilization of the natural draft is obtained gratuitously.

In addition only a very small fraction of the volume of the gases is passed through the fan to give it an adequate live pressure—a twofold reason for a fan of small bulk. This live pressure is used in the manner of the impulse jet of an ejector to create the necessary negative pressure for the induction of the gases; whence the name "pressure transformer" given to the Prat chimney.

In effect the power here furnished is nothing more than a simple acceleration of the natural draft, automatically variable within certain limits, and the fan acting on the reduced orifice, can be chosen to suit the maximum service.

Concerning the limitations of the direct and suction systems, of the former those styled compensated, balanced, etc., are in fact pressure drafts and include the automatic damper regulator. These systems have as their guiding principle the automatic maintenance in the furnace of a pressure equal to that of the atmosphere, thus reducing the leakage of air into the furnace. In reality the furnace is not at zero pressure but under a slight negative pressure which increases in a negative direction up to the damper. The richer the coal the less it is possible to approach the zero pressure in the furnace on account of the smoke action at the time of firing.

The advantage of the diminution of air entrance is acquired at the cost of complications including an auto-

matic regulator to control the speed of the fan and an automatic regulator to control the draft.

As to the suction system it avoids the complications inherent in the forced or balanced systems of subgrate air supply. The installation is simple, the losses due to elbows are smaller and the destruction of the grates disappears; but, as seen, it means fans of abnormal dimensions. For a battery of large boilers, as in a central station, it would be practically impossible, and to avoid this difficulty a fan is used too small for the opening through which it must operate.

The general arrangement of the induced system designated as a "pressure transformer" (Fig. 4) includes essentially a metal plate stack comparable to an ejector of which *C* is the converging portion, *A* the chamber and *B* the diffuser. The negative pressure inducing the flow of the gases is created by a fluid impulser furnished by a fan blower and injected into the chamber by the nozzle *D*. In case of a stoppage of the fan the impulse is produced by an emergency steam ejector *S*.

This fluid impulser can be either the cold air taken from the atmosphere or the hot gases taken from the flues. With the former method, called "outer circuit," (Fig. 4) the fan is entirely outside of the current of gases and consequently under the best conditions for its maintenance and preservation. In all cases the addition of the cold air lowers the temperature of the gases and the degree of utilization of the natural draft is diminished in proportion to the cooling.

With the latter method, known as the "inner circuit" (Fig. 5) the fan runs in the heated gases as in the ordinary suction draft; but the injection of cold air is done away with and the power needed becomes extremely small.

Mechanical draft has often been criticized as having a lesser degree of certainty than chimney draft, as failure of its operating source or its injury will cause the fan to stop and almost entirely suppress the draft. The only safety against such a contingency is an auxiliary or emergency fan; meaning a considerable increase in the first cost of installation and in the space occupied.

In the Prat system the emergency provision is represented by a steam jet blower as shown in Figs. 4 and 5. Contrary to the case of ejectors used for blowing beneath the grates it is here permissible to select such dimensions as will promote a satisfactory utilization of the steam, of which the consumption for this auxiliary draft is by no means great. Furthermore, the operation of this ejector in conjunction with that of the fan permits doubling the draft, a matter of perhaps great utility at a time of unusual demand for steam.

It often happens with existing plants that the desire is to increase the draft of the present chimney. The Prat system is especially adapted to such cases, its small bulk permitting its being placed inside of the chimney, and besides there is retained all the benefits of the natural draft due to the height of the chimney.

In conclusion the pamphlet states that the advantages of mechanical draft are less and less disputed as its application becomes more widespread. The principal points in its favor are elasticity of production, economical combustion, rendered easy by the facility of regulation of the exact amount of air in relation to the combustible used; and variability of the pressure produced, independent of atmospheric changes and boiler operation.

Coon Creek Rapids Development

Active construction of the water-power development known as Coon Creek Rapids, 11 miles northeast of Minneapolis, has been started by H. M. Byllesby & Co. It will have an initial capacity of 12,000 hp. and will furnish additional power to the Minneapolis and St. Paul properties.

The dam is being built under a permit granted by Act of Congress. This act requires that the construction and operation of the dam are to be carried out under the supervision of government engineers. The permit is for a period of 50 years.

The dam will consist of earth embankment with core walls 600 ft. long, a power house and retaining section 470 ft. long, including sluice gates, log chute and fishway; and a spillway section 1000 ft. long, making the total length of the structure 2070 ft. This work will involve 20,000 cu.ft. of earth embankment and approximately 45,000 cu.yd. of steel-reinforced concrete.

To secure a suitable and safe foundation, there will be used in the construction approximately 8000 round wooden piles, driven down to firm foundation. There will also be used 1000 tons of interlocking sheet-steel piling in lieu of a cutoff wall for retention of water in the reservoir and to prevent under-cutting of the dam.

For the greatest possible head at all stages of river flow and to prevent excessive flood heights, Tainter gates will regulate the water-level in the reservoir. Twenty-eight of these steel gates, each 12,000 lb. in weight and 33 ft. long, will be erected between reinforced-concrete piers built on the spillway portion of the dam. The fishway, designed in accordance with government requirements, will provide for the free passage of fish up and down stream, and the log sluice will have a convenient means for passing logs by the dam.

The first installation will provide for 12,000 hp. with the most efficient type of waterwheel units driving enormous electrical generators, which will transmit current to Minneapolis at 13,300 volts, thus tying in directly, without transformers, with the general distribution system of the Minneapolis General Electric Co. at the Riverside steam plant. The transmission line for conveying the electric current to Minneapolis will be erected part of the way on private right-of-way and along the right-of-way of the recently completed tracks of the Minneapolis & Northern R.R.

A construction camp has been established at Coon Creek Rapids, and a camp for 400 men provided, to be increased later to accommodate 800 to 1000 men during the spring and summer months. The camp is equipped with its own water-supply and sewage system. Following modern methods, a hospital, with a surgeon, trained nurses and attendants, will be in operation during the construction. All matters in relation to water supply, sanitation and policing of the camp will be handled in the same way as they would be handled for a modern city. The camp will be electrically lighted throughout, current being supplied for this lighting by the Minneapolis General Electric Co. Electric current will also be used for driving a considerable portion of the construction plant.

During the construction of the dam there will be distributed for labor and commissary supplies, approximately $600,000. The housing and feeding of the construction men are in themselves an enormous undertaking.

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Field-magnet Cores

Generally the polar end of a field-magnet core—that end which is nearest the armature—is enlarged, as represented in Fig. 140. The object is to reduce the magnetic force required to drive the flux across the airgap. Magnet cores are usually of steel and to economize in material the cross-section of the core is made of such an area that the magnetic density in the core is about 90,000 to 100,000 lines per sq.in. If the polar end of the core were left unenlarged, as in Fig. 141, the density in the airgap would be so high that an excessive magnetizing force would be required.

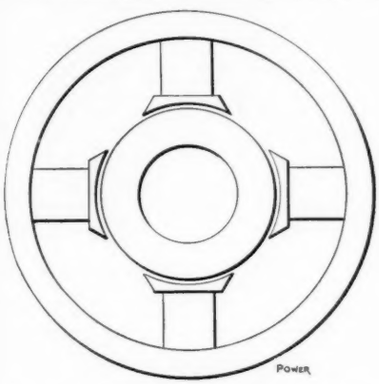


Fig. 140. Modern Four-pole Field Magnet

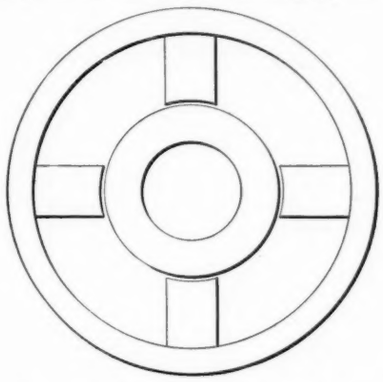


Fig. 141. Field Magnet without Polar Extensions; High Airgap Density

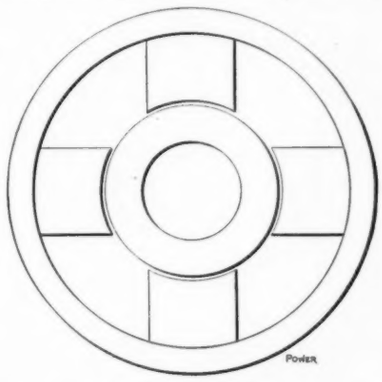


Fig. 142. Field Magnet without Polar Extensions; Normal Airgap Density

For example, with the construction shown in Fig. 141 and a magnetic density in the core of 90,000 lines per sq.in. of cross-section, the density in the airgap would be about 80,000 lines per sq.in. With this density, if the airgap were ¼ in. long, it would require

$$80{,}000 \times 0.3133 \times \tfrac{1}{4} = 6266$$

ampere-turns to force the flux across the airgap. With polar extensions, as in Fig. 140, the area of the airgap could be increased enough to bring the magnetic density down to about 50,000; at that density the magnetizing force required to drive the flux across would be only five-eighths of 6266, or 3817 ampere-turns.

It is possible, without using polar extensions, to keep the density in the airgap down to a reasonable figure by making the magnet cores larger than necessary, as illustrated in Fig. 142, where the airgap area is the same as in Fig. 140. This construction is used in some small machines built with cast-iron magnets, but it is not used in machines of larger size because of the waste of material and increased weight entailed. In some cases the weight of the magnet has been kept down by slotting the core as indicated in Fig. 143, but even with this arrangement an excessive quantity of copper must be used in the field winding because of the larger girth of the core as compared with the type illustrated in Fig. 140. Moreover, this form of core usually results in an increase in the diameter of the yoke ring, because the magnet coil cannot be made as thick (at right angles with the length of the core) as when the smaller core is used and it must therefore be made longer to get enough wire in it to prevent overheating.

The slotted form of magnet core is advantageous, however, in preventing great distortion of the airgap flux by armature reaction,* and it has been used successfully for that purpose by a few builders. When so used, however, it is not necessary to make the core the full width of the airgap, as in Fig. 143; the slot is made very narrow and the core is made with polar extensions somewhat as in Fig. 140, except in one instance where only one extension is used, as shown in Fig. 144. This is a very special form of construction, however, and scarcely comes within the scope of general elementary discussion.

Core Cross-sections

Magnet cores are made in several forms as to cross-section, and even though the student may never have occasion to design or build a dynamo, the influence of different forms and the reasons for using them are of practical interest.

On account of the cost of copper, the field-magnet core is usually made with a view to economizing in the use of magnet wire, even though some increase in the cost of the core or frame may be entailed. The form of core cross-section which theoretically should be used to obtain the greatest economy in wire is round; the form which comes next in line is octagonal with rounded corners; next oblong with rounded ends, next square, and so on.

Fig. 145 shows the relative lengths of wire necessary to reach once around different practical forms of core, all of the same cross-sectional area. The distances around the

*The effect of armature reaction upon the airgap flux was briefly referred to in one of last year's Primer lessons. It will be explained fully in a future lesson.

outside of the cores are expressed in percentages to afford easy comparison. The circle is put at 100 per cent. because it has the smallest girth. The figures indicate that a square core requires about one-eighth more wire to "surround" it than a circular one, and a 2-to-1 rectangular core nearly one-fifth more. But this does not mean that the quantity of wire required in the complete coil is one-eighth and one-fifth greater, respectively. When the girth of the coil is large, its length parallel with the core can be made smaller, in most cases. This point will be discussed fully in a later article on windings.

The shape of a magnet-core cross-section is largely determined by the material of which the core is made.

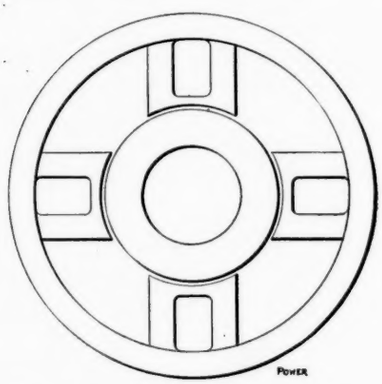


FIG. 143. MAGNET CORES SLOTTED TO REDUCE WEIGHT

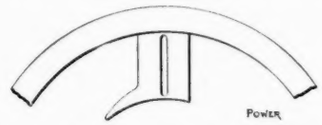


FIG. 144. CORE SLOTTED TO PREVENT FIELD DISTORTION

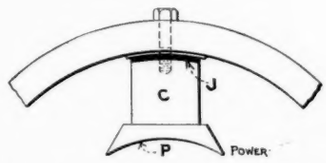


FIG. 146. MAGNET CORE BOLTED TO YOKE

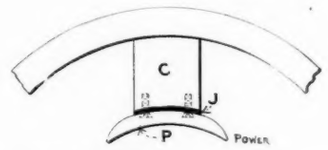


FIG. 147. MAGNET CORE INTEGRAL WITH YOKE

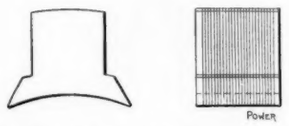


FIG. 148. LAMINATED MAGNET CORE

When cast iron is used the cross-sectional area must be nearly twice as great as when steel is used, because the magnetic density in cast iron cannot be carried much above one-half of the density in steel, which requires about the same excitation in the field winding. For this reason it is important to make the girth as small as possible for a given cross-section. Therefore, a cast-iron core should logically be made with a circular cross-section if possible. When steel is used, the form of the cross-section is not so important so far as economy of field-magnet wire is concerned and the shape is determined more by the method of constructing the magnet than anything else.

ence to the lesson on this subject* is advisable. Another reason for using laminated magnet cores is that thin pieces of iron or steel become magnetized and demagnetized more quickly than thick pieces, and a laminated core will therefore respond to changes in field excitation more quickly than a solid core will. Some small machines are built with the entire field magnet laminated. The reason, however, is not a technical one; the main object is economy in manufacture.

When the yoke ring of a machine is of cast iron and the magnet cores of steel or wrought iron, the form of construction shown by Fig. 146 is not advisable. The flux density in the magnet core is much higher, as a

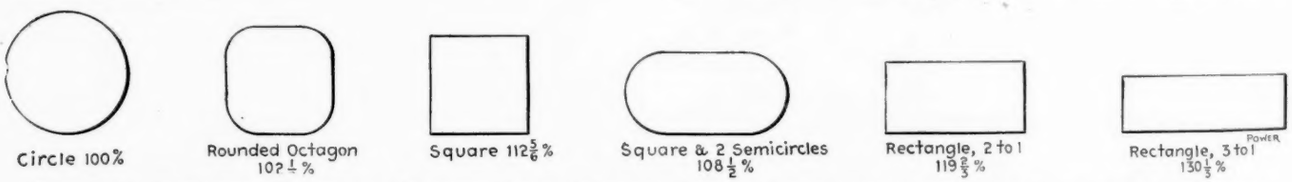


FIG. 145. RELATIVE GIRTHS OF MAGNET CORES HAVING EQUAL CROSS-SECTIONS OF DIFFERENT PROPORTIONS

Figs. 146 and 147 illustrate the two methods of "making up" field magnets which are most used. On account of the usual necessity of enlarging the end of the core nearest the armature, the core must be made removable from the yoke to get the magnet coil on it, or else the enlarged end must be removable from the main part of the core. Fig. 146 illustrates the former construction, the heavy line J indicating the joint between the core and the yoke; the enlarged portion P is made in one piece with the core proper. Fig. 147 illustrates the other construction, in which the enlarged part P is attached to the core C along the line J. With this construction rule, than cast iron can be worked economically, and the excitation required to force the flux into the cast-iron face at the joint J would be too great to be practical. In such cases, to avoid excessive densities in the cast iron at and near the joint, the method of construction most used is to cast the yoke around the ends of the magnet cores. Fig. 149 illustrates such construction. The "heel" of the magnet core is grooved and the cast iron flows into the grooves and holds the core tightly in place. The grooving also serves to increase the area of contact between the cast iron and the steel and thereby reduce the

*Power for Apr. 19, 1910.

resistance to the passage of magnetic flux between the two metals. (This magnetic resistance is called "reluctance".)

Casting the yoke metal around the ends of the magnet cores is not easily done satisfactorily. The flow of the molten iron almost invariably shifts the magnet core in the sand mold, and sometimes the hot iron is chilled by the cooler steel to such a degree as to cause it to shrink and leave an imperfect contact. To avoid this method of construction and still retain the iron yoke and steel cores, machines have been built on the principles illustrated by Figs. 150 and 151.

Fig. 150 shows a wrought-iron or steel plate *S* inserted between the heel of the core and the yoke. This

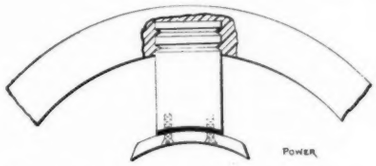


FIG. 149. IRON YOKE CAST AROUND STEEL MAGNET CORE

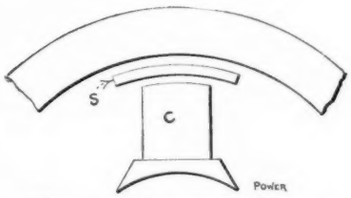


FIG. 150. INSERTED FLUX-SPREADING PLATE

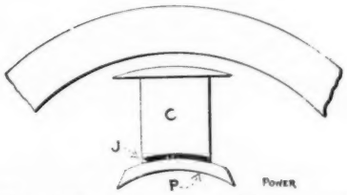


FIG. 151. CORE WITH EXTENDED HEEL AND REMOVABLE POLESHOE

serves to give the flux a path of low reluctance through which to "spread" in its passage between the core and the yoke. The construction in Fig. 151 does the same thing, but the spreading plate is in one piece with the magnet core, and the core is therefore provided with a removable poleshoe. Both of these methods have proved rather expensive in manufacture and for that reason neither has come into general use.

Switchboard Losses

The article in the Feb. 25 issue on "Improving the Conductivity of Joints," leads me to write on a matter very similar in character.

There are apparently few engineers or designers of power plants, particularly among the small ones, who consider the value of high-grade instruments, especially with reference to the use of voltmeters requiring a very small current; ammeters whose moving coils are operated by a very small current, or whose shunts have a very low resistance; switches of sufficient capacity in the blades as well as sufficient contact area in joints and jaws to give a low drop; and circuit-breakers designed under similar conditions.

In a power plant having a large number of these devices, the loss due to the foregoing causes can amount to a very large sum of money, far more than paying the difference in cost between good and bad installation. This condition of affairs is usually far more serious than the loss of power over joints. For instance, if a voltmeter on a 550-volt circuit, requires 0.2 amp. to give it full scale reading and it is in use continuously, the loss per year, based on power at 2c. per kw.-hr., would be $19.44; whereas with a voltmeter requiring only 0.01 amp., the loss would be 97.2c., showing a yearly loss of the former over the latter of $18.46, or representing an investment value of $307.40 based on interest at 6 per cent. This shows very conclusively that the difference in the cost of the two instruments would be more than made up by the power saved.

Consider a shunt of 10,000 amp., having a drop of 50 millivolts, and another one of 80 millivolts. The loss in the first case with power at 1c. per kw.-hr. would amount to $43.80. In the second case it would amount to $70.08, a difference of $26.28, representing an investment value of $438. This, of course, is on the basis of the instruments being operated at full capacity continously. If the average load is one-half this, the investment value would represent $219, which would more than pay the difference in the cost of the two types of instrument and shunt.

It is not uncommon for power plants, having increased their capacity, to changes the capacity of the ammeters by inserting additional resistance in the moving coil circuits, in order to increase the range of the shunt. In one plant where this was done, the range was changed from 60 to 122 millivolts. The loss with power at 1c. per kw.-hr. was $160.80 per year, representing an investment cost of $2680. The cost of replacing the shunt would not have been more than $300, including labor, showing a saving of $142.80 per year.

The same method of figuring might be carried through switches and circuit-breakers to advantage. Of course, the value of doing this depends largely upon the cost of power.

The same condition might readily occur in connection with wiring. It is frequently possible to lay out wiring where the drop may not be sufficient to cause any difficulty in the operation of lamps or motors; but this is not the only thing to be looked out for. If the loss over these wires is figured, it will many times be found advisable to install more wire than enough to allow operating voltage, as the interest on the increased cost of the wire will be less than the cost of the power saved by the smaller wire.

HENRY D. JACKSON.

Boston, Mass.

A 20,000-kw., 13,200-volt, 60-cycle Westinghouse turbo-generator is to be installed at the Marion plant of the Public Service Co. of New Jersey. A still larger unit is being built by the same manufacturers for the United Electric Light & Power Co. of New York. This is a 22,200-kw., 11,000-volt, 25-cycle machine.

GAS POWER DEPARTMENT

Producer Gas in Heating Furnaces

By Everard Brown

One of the principal advantages in the use of natural or artificial gas is that both can be burned in either regenerative or recuperative furnaces. This permits a furnace being so designed as to obtain comparatively low temperatures of the waste gases.

Natural gas, in locations where nature has provided it in sufficient quantities for manufacturing purposes, is, of course, preferable to the artificial or producer gas because it can be transported long distances, worked under pressure and, being cleaner, can be burned much more efficiently. Its use also eliminates all of the labor costs and troubles incident to the manufacture of producer gas, although the importance of this factor depends entirely upon the comparison between the cost of the one and the cost of manufacture of the other. As for burning coal either regeneratively or recuperatively, experience has demonstrated that it cannot be done successfully, at least with the present-day equipment. The chief obstacle in the use of coal for this purpose is that the checker-work in the regenerative chambers and the flues soon clog with heat. Another difficulty is that the grate bars burn out quickly, particularly with the introduction of a hot blast.

Considerable heat is lost in the transformation of coal into gas, nevertheless this loss is amply compensated for by the use of regenerative chambers as compared with burning coal direct in an ordinary furnace. For instance, assume that a pound of coal contains 13,500 B.t.u. In transforming this coal into producer gas there is loss of about 20 per cent. in gasifying, heat carried away in the ashes, radiation losses, etc. There is available, therefore, about 10,300 B.t.u. for heating purposes. But, owing to radiation and other losses in the furnace consuming the gas, this available amount is further reduced to about 9200 effective heat units. In burning this pound of coal direct in a furnace there would be practically the same losses that occur in the gasifying process, so that by the direct-firing method there would be 1100 heat units—the difference between 10,300 and 9200—more put into the furnace than by the other method. To offset this difference in favor of the coal, however, it must be remembered that the gas can be well and thoroughly mixed with air, thus resulting in more perfect combustion. The net result is, therefore, that the two methods are very evenly balanced as far as the actual input of heat into the furnace is concerned.

It is apparent, then, that any great advantage to be found in the use of producer gas must be looked for in the furnace itself. In the case of a regenerative furnace, general practice has shown that approximately 20 to 25 per cent. of the original heat value in the coal gasified goes into the material to be heated in the furnace. On the other hand, where the coal is fired direct into an ordinary furnace which, consequently, cannot have regenerators, the stack temperatures are exceedingly high so that the efficiency of the furnace is generally not more than 10 per cent. That is, it will require about 2 lb. of coal fired direct to attain the same results as with one pound consumed as gas. If coal is worth $1.50 per ton and the expense of firing it directly into the furnace is equal to that of making producer gas and assumed to be 25c. per ton, then the producer-gas method of firing would result in a net saving over the direct-firing method of $1.75 per every ton consumed.

In this connection, however, it must be remembered that the use of producer gas in preference to the direct firing of coal will show an appreciable advantage and gain in economy only in such furnaces as will give relatively low stack temperatures. For example, in a long, continuous heating furnace where a stack temperature in the neighborhood of 600 deg. can be had, the economy in using producer gas is rather doubtful. It is also well known that for firing boilers producer gas does not give nearly as high efficiencies as are obtained with coal.

One of the greatest factors in the successful operation of a gas-producer plant is the proper kind of equipment. For example; a water-sealed producer with a revolving grate will gasify probably 10 per cent. more coal per square foot of grate area than that with a stationary grate; due largely to the time lost in suspending operations every time the stationary grate is cleaned. Furthermore, there is some gain in the water seal, because the heat in the ashes, which would otherwise be dissipated, generates some steam, which helps to keep the fire in a better condition. There appears to be, however, some difference of opinion as to the capacity of the water-sealed producer compared with the ordinary grate type.

The cost of repairs and maintenance incident to the manufacture and burning of producer gas should not be a serious consideration. Ordinarily, this item should be no higher than for the ordinary coal-fired furnace, as the temperatures in the producer are rarely as high as in a furnace.

The question of coal, however, is quite important. The best results are usually obtained with a coal containing a high percentage of volatile matter, but low in ash and of such a composition that it will not fuse and clinker badly. The best depths for the fuel bed are given from 2½ to 7 ft.

All pipes, flues and connections should be amply large. In the first place, small ones quickly choke with soot, and a higher pressure is required to force the gas through them. Secondly, with ample sized pipes and flues there is proportionately less radiation. It might be argued that the condensation of the gas would be reduced by using smaller flues and pipes because of the higher velocity of the gas through them, yet, on the other hand, the temperature losses would be proportionately greater, which would probably cause even greater condensation.

About the maximum distance that producer gas can be successfully carried is 400 ft. The question then arises whether it is better to have the producers in groups when

serving several detached furnaces or to have single producers adjoining the furnaces. In the first case coal- and ash-handling machinery can be installed which will lower the labor cost considerably. It is also true that a better and more uniform gas is obtained. The disadvantages of such an arrangement, on the other hand, are radiation losses, leaks that are more apt to develop in a long line than a short one, and the burning of the gas in the producers. A little figuring, however, will show that it requires a much greater loss, due to radiation, leaks, etc., than occurs in ordinary practice to offset the gain in labor saving by grouping the units.

As to the amount of steam required to operate gas producers, there is but little authentic data and no general rule can be given. The character of the coal used has much to do with this question as more steam is needed for coal which clinkers badly than for that which does not. The size of the gas mains and the capacity at which the producers are worked are also determining factors. In a general way, however, it may be stated that under ordinary conditions not more than from 2 to 5 per cent. of the heat units in the coal are needed to generate sufficient steam. As some of this heat is returned to the producer, the actual loss is less. If possible, the steam used should be superheated to prevent condensation and moisture for, if wet steam is introduced, a chilling action might result from reëvaporation. It has also been found that a hot blast gives better results than a cold one. The pressure at which a producer is blown usually ranges from 30 to 40 lb. per sq.in.

One of the worst troubles in connection with gas-producer operation is the nonuniformity of the gas. Very often this is the result of poor attention and could be remedied by a little extra watchfulness to see that the fires are kept level and free from holes, that the coal is fed at proper intervals, that the necessary poking is done, and that the proper amount of steam is introduced, etc. There also seems to be universal trouble in securing good men for this class of work which really requires as much, if not more, skill than firing boilers.

To eliminate as many of the troubles as possible resulting from the improper handling of producers, there are now several types on the market having more or less automatic attachments. However, an expert fireman can probably get better results than can be obtained through the use of any automatic device. Experiments with water-cooled, automatic pokers and automatic-feeding devices have brought about considerable improvement, as has also the principle of rotating either the whole or a part of the producer itself. The charging of coal through chutes from overhead bins, on the contrary, is an improvement of doubtful value as this practice allows the coal to come down with a rush, making it difficult to properly regulate the quantity charged. This is particularly true with run-of-mine coal. If the coal were crushed to a uniform size and the slack screened out, the results would no doubt be much better in this respect.

A 15,000-hp. Pelton wheel, believed to be the largest unit of the type in Europe, is being installed in the Löntsch hydro-electric power station on the Klonthalersee near Glarus. The present installation consists of six 6500-hp. Pelton wheels, directly connected to their respective generators. The new unit will increase the capacity of the station from 39,000 to 54,000 hp., making it the largest in Switzerland. The new turbine will be constructed by Theodor Bell & Co., of Kriens, and the electrical equipment by Brown, Boveri & Co., of Baden.—"Engineering Record."

Largest Diesel Engines in This Country

Phelps, Dodge & Co., New York, have recently purchased two 1000-hp., two-stroke-cycle, four-cylinder Carels-Diesel engines for installation in one of their Arizona mining properties.

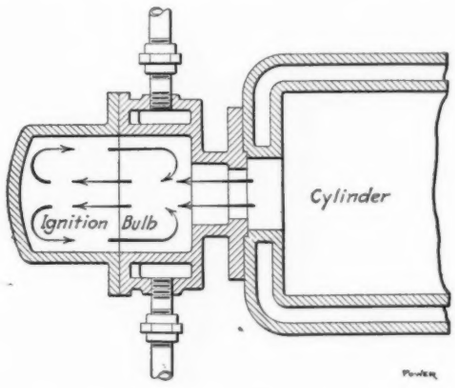
Special interest centers about these engines in that they are the largest of the Diesel type to be erected in this country. They will be direct-connected to 60-cycle alternators to operate in parallel, and are guaranteed to deliver 1000 hp. at an elevation of 6500 ft., using not more than 0.48 lb. of oil per b.hp.-hr. A number of similar engines are now in use for central-station service in Brussels, Paris and Bucharest.

CORRESPONDENCE

Igniters for Oil Engines

Oscar P. Ostergren, in his article on "Classification of Oil Engines," Feb. 11 issue, referring to the Hornsby type of bulb igniters for oil engines, says: "The principle represented in Figs. 4 and 5 is extremely simple." He follows this statement by a very brief description of the action of such an igniter. This apparatus, although very simple in construction, seems to me to be very complicated in principle.

For proper ignition, it is necessary to bring a correctly proportioned mixture in contact with the walls of the bulb for sufficient time and at the right time to raise a part of it to the ignition temperature. The bulb is heated by a torch for starting and by the heat of combustion of the oil while the engine is running. The oil is injected into the bulb during the latter part of the suction stroke in the form of a solid stream which impinges against the side of the hot bulb. Some of it is vaporized immediately, and some of it later by the heat



SECTION THROUGH IGNITION BULB

of the bulb. The bulb now contains oil vapor (and possibly some unvaporized oil) and products of combustion from the previous explosion. Combustion does not occur at this point because there is no air to support it. As the compression stroke starts, air is forced from the cylinder into the bulb. The manner in which this air enters causes currents to be set up in the mixture in the direction shown by the arrows in the sketch. Due to the variation of the piston velocity these currents are

slow moving at the beginning of the compression stroke, rapid at the middle of the stroke, and slow again at the end. Toward the middle of the stroke there may be enough air in the bulb to make an explosive mixture, but these currents are then moving with such a high velocity that no one portion of the mixture comes in contact with the hot walls of the bulb long enough to be heated to the ignition temperature. As the piston approaches the end of the stroke, the circulation slows down, and when the combined heating actions of the hot bulb and compression bring any part of the mixture to the ignition temperature, an explosion occurs. A portion of the bulb is covered by a jacket space, and, therefore, by varying the cooling-water temperature (or when designing, the amount of jacket space at this point) it is possible to vary the temperature of the bulb and consequently the timing of ignition. Thus with proper care in operation and design, the "danger of premature ignition" should be very small.

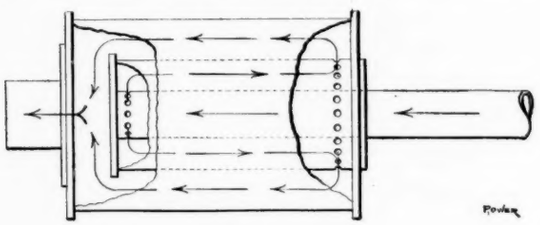
WILLIAM J. DEMOREST.

New York City.

Exhaust Muffler

The temporary exhaust pipe from the first big gas engine installed in the power house of the Ford Motor Co., at Detroit, was a simple straight run of 14-in. pipe extending vertically along the outside wall of the power house. While the noise from the exhaust was not excessive, it was found to be somewhat objectionable, and a muffler was fitted to the end of this pipe, built as shown in the accompanying sketch.

This muffler is simply a large size of exactly the same



FORD MUFFLER

type as is used on the Ford cars and was found to be extremely efficient. The noise from the exhaust is scarcely audible on the ground just outside the power house.

This muffler can easily be built of various sizes of ordinary pipe. The labor cost is low and the result is extremely satisfactory.

L. L. BREWSTER.

New York City.

Test of Producer Plant

Referring to the article under the above caption in the Feb. 4 issue, I recognize the plant in question as the one in which I was night engineer for over a year. I was disappointed at not getting a fuller report of the test and would ask Mr. Brewster to state more of the operating conditions. What are the average and the peak loads? How much of the normal capacity of the three 100-kv.-a. units is utilized? Also, how much power is supplied to the factory by the central station and how much does this cost? Furthermore, he does not state the cost per kilowatt-hour, the cost of maintenance, nor why the owners wanted the test made.

Mr. Brewster says there was no tar found in the gas. Can he tell us what that black, gummy substance is that plugs up the rotary exhaust scrubbers, heavily coats the inlet valves and manifold and rolls up in the form of a ball in the ends of the inlet manifold? I should also like to know whether he discovered the cause of the rapid corrosion (or whatever it is) of the valves, especially the inlet valves, which requires them to be cleaned and ground about every two weeks.

I have some very interesting data on this plant, which would indicate why the owners wanted a test made and also why the central station frequently gets in where it has no business to be, but I would like to hear from the author of the article first.

An average of 3.08 lb. of fuel per kw.-hr. looks rather high for a "thoroughly modern plant" operated by a "crew well above the average." Our plant is not nearly so large nor so thoroughly modern and our standby is 109 hr. of the 168 hr. per week; yet, our coal consumption (Lykens Valley pea) is slightly less than 2 lb. per kw.-hr.

L. L. DOUTHAT.

Jersey City, N. J.

Steam in Producer Room

While in charge of several pressure gas producers, considerable trouble was experienced with steam arising from the surface of the water in the top of the producer. One very cold morning, when entering the producer room, I could hardly see the men because of steam, which, together with the gas coming from the poke holes while working the fuel bed, made it very hard for the men to keep from being overcome.

I conceived the idea that if a film of oil could be kept on the surface of this water, the trouble might be lessened. Therefore, I cut a piece of tin and formed it around the overflow in such a manner that the water going to the overflow would have to pass under this tin while the oil would not. By putting about a quart of oil on the top of each producer, the steam at once stopped, and, in many places, the oil was so thin that I could see the producer top through it.

M. W. EASTMAN.

Cambridge, Mass.

What Caused the Pound?

In answer to Mr. Abel's inquiry in the Jan. 28 issue, I would say that I have encountered the same trouble in multi-cylinder vertical engines, and have always found that the pound was caused by some of the other cylinders not performing their share of the work, thereby putting an overload on the cylinder which was operating all right. This causes excessive heat in that particular cylinder and the igniter becomes so hot that it holds fire and causes early ignition, which cannot be regulated by the timing device.

The trouble may be due to leaky valves, but most generally will be found in the igniters.

H. H. DELBERT.

Titusville, Penn.

HEATING AND VENTILATION

Room Temperature and Radiating Surface*

A consideration which has not been scientifically studied, is the question of the proper temperature at which the air in a room should be maintained. In the United States, it is customary to assume that a temperature of 68 to 70 deg. F. is most suitable for rooms in which persons are not actively engaged. In Germany, for similar rooms, a temperature of 65 to 68 deg. F. would be regarded as sufficient, while in England a room is considered properly heated when the temperature is 55 to 60 deg. F. In one of the great English universities, classes are often held in rooms when the temperature does not exceed 55 deg. F., but, under the same conditions, in the United States, the class would be dismissed. What is the reason for this difference of temperature required by different nationalities? Is it due to personal peculiarity, custom or climatic conditions? Possibly the proper temperature in one locality may be different from that of another. The outside temperature may have much to do with the temperature required indoors, as it is a well known fact that people living in countries where the temperature is extremely low usually require higher indoor temperature.

Many rules have been proposed for determining the proper amount of radiation to be placed in a room, and practically all of these rules are based on the assumption that the heat so applied to a room shall equal the heat lost from the walls and the windows. There are other conditions entering into the determination of the proper amount of radiation that should be placed in a room which are often allowed for by adding on percentages, but the percentages allowed in most cases are not based on any scientific hypothesis. For example, the intermittent heating of a room will affect the amount of heating surface to be placed in the room and the amount added will depend upon how quickly it is desired to heat the room after it has been cooled.

Where buildings are intermittently heated, or are of heavy construction, far more heat is required to warm the walls of the building in a reasonable length of time than to take care of the heat transmission. Again, most of the rules used in determining the amount of radiation to heat a given sized room assume that the room must be heated at a temperature corresponding to the lowest temperature which exists outdoors for any length of time. Theoretically, such a proposition is absurd, as, obviously, if just enough heat was supplied to provide for the heat lost from the room and the conditions all remained constant, it would require an infinite length of time to warm the room. Fortunately, the heating engineer figures the radiation to heat the building at a much lower temperature than the average; and during the warm days heat is stored in the walls from the excess given off by the heating plant and absorbed by the sun. During the very cold days this heat is given up and reduces the heat loss from the building, serving to correct the errors in the engineer's calculation. In many of the great cathedrals of Europe no heating system is provided and these buildings are never uncomfortable, owing to the heat stored in the building structure during the summer months and returned to the air during the colder months. A good example of the use of heat stored in a building comes from Germany.

Recently a state dinner was to be given in a castle which had no heating system. The engineers were asked to heat the building for the dinner; but it was specified that no portion of the heating system was to be visible in the room. The result was accomplished by means of stored heat. For a number of days previous to the dinner, the floor of the dining room was covered with steam pipes and these pipes were kept hot by means of a temporary boiler. The day before the dinner all the pipes were removed and the stored heat in the walls maintained the room in a perfectly comfortable condition for a number of days, although the outside temperature was well below the freezing point.

None of the rules for heating take these conditions into consideration. It is quite possible that it would be better in buildings of heavy construction to base the necessary amount of heat to be supplied not upon the minimum external temperature, but, rather, upon the average external temperature. Most heating engineers allow a large margin of safety which covers their ignorance of the conditions entering into the problem.

*Excerpt from Prof. J. R. Allen's presidential address to the American Society of Heating and Ventilating Engineers.

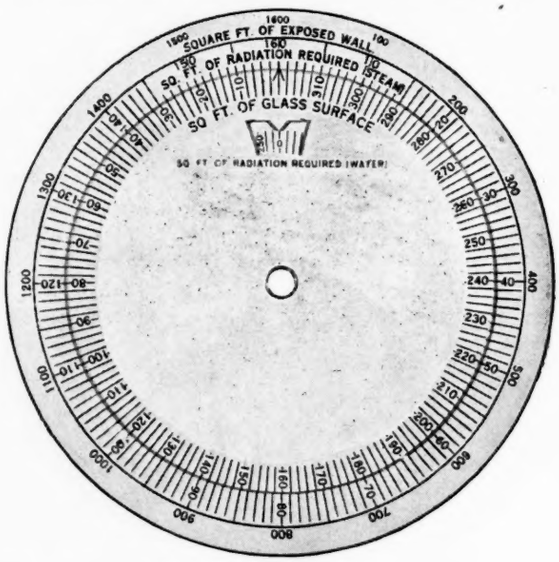
Calculator for Residence Heating

A convenient calculator for computing the square feet of radiation for steam or gravity hot-water heating in a residence has been copyrighted and placed on the market by the Novelty Calculator Co., of Watertown, N. Y. It is arranged in convenient form on a celluloid card, 3x4½ in., together with full directions for operating and an example to illustrate the process. The arrangement of the calculator is shown in the accompanying illustration. By placing the square feet of glass surface opposite the square feet of exposed wall surface, the square feet of radiation for steam will be found opposite the arrow on the dial; or, for hot water, opposite the pointer in the window. The calculator is based on an outside temperature of zero and a room temperature of 70 deg. F., a difference of 70 deg. If the temperature is lower than zero outside, the proper amount of radiation may be computed by means of a second calculator on the opposite side.

In laying out the calculator, the heat loss through the walls was taken as 0.344 B.t.u. per sq.ft. per hr. per deg. difference, or 24 B.t.u. for 70 deg. difference, and the heat loss through a square foot of glass as 1.71 B.t.u. per hr. per deg. difference, or 120 B.t.u. for 70 deg. The

ratio of glass to wall surface appears to be 1 to 10. With steam at 2 lb. pressure, the radiation per square foot was taken as 240 B.t.u. per hr., and for hot water, with a temperature of 180 deg. at the boiler, as 180 B.t.u. per hr. The coefficients of heat loss through the walls and glass surface were purposely made high to allow for air change through leaky doors and windows and irregularities in the heating system, which are sometimes necessary and tend to reduce the efficiency of residence heating.

When the room is of such size as to overrun the limits of the calculator, the arrow will not indicate enough



FACE OF CALCULATOR

radiation. By observing the following rules this difficulty may be avoided.

Reading clockwise, if the arrow is between the determined wall surface and 160 sq.ft. of steam radiation, the results are as shown.

Reading anti-clockwise, if the arrow is between the wall surface and 160 sq.ft. of steam radiation, add 160 to the result shown.

❖

Operating Cost of Indirect Heating Systems*

BY FRANK L. BUSEY AND WILLIS H. CARRIER

The object of this paper is to show that there is a definite relation between the cost of power and the cost of the apparatus, and to determine what ratio between these two factors will insure the lowest practical yearly outlay to cover the cost of power, as well as an allowance on the cost of the installation to care for interest and depreciation. It will be found there are two power requirements to be met at the fan of a hot-blast heating system, one due to maintaining the required velocity head and the other depending on the loss in pressure due to the frictional resistance of the system. The first item is fixed when the velocities through the system are decided upon. The second item of requirement is due to two sources—the resistance through the heater and the friction through the piping and ducts of the distributing system. These are two separate sources of pressure loss, and either one may be studied independently of the other and changes made, as one does not necessarily affect the other. Inasmuch as with a constant air quantity the friction loss varies as the square of the velocities of the air through the heater or ducts, it is seen that the resistance due to velocity is the factor to be considered.

In general, the law seems to hold that the rate of heat transmission varies with the frictional resistance of the heater. The relative efficiency of two heaters should be based on the rate of heat transmission under identical temperature conditions and with equal pressure losses in forcing the air through the heater, and not upon the so called velocity through the clear area, which is more or less a hypothetical quantity.

Any decrease in the velocity of the air through the heater means an increase in clear area with a decreased rate of transmission and a consequent increase in total surface required. It also reduces the friction and, therefore, the horsepower required at the fan, with an increase in the size of the fan and a decrease in the size of the motor. To get the same heating effect, the depth of the heater must be inversely proportioned to the square root of the total surface, or directly, as the square root of the rate of transmission is determined by the velocity. The horsepower and the pressure loss vary directly as the seven-thirds power of the velocity when the heater is proportioned to give the same temperature rise to the same quantity of air. The formulas, expressing these relationships, together with their derivation, are all included in an appendix.

It might be well to suggest in this connection that increasing the surface of the heater by the use of the additional sections will not answer the purpose intended, as this would increase the pressure and power required. The increase in surface must be obtained by using larger sections with the greater clear area, so as to handle the same amount of air at the reduced velocity, using the same temperature rise.

The method of assuming a total pressure against which the fan is to operate and then so proportion the various pressure losses as to keep within this limit fails to take into consideration the power cost of the fan. That this is an item of more than secondary importance will be shown, together with the relation of the cost of installation to the subsequent cost of power.

VELOCITY OF MAXIMUM ECONOMY

Assuming a static efficiency of 40 per cent. for the fan —that is, 40 per cent. of the brake horsepower consumed by the fan is usually employed in moving the air against static resistance—the horsepower required due to any resistance or pressure drop through the heater will be the product of the air handled times the pressure drop expressed in inches of water times a constant 0.000405. Expressed as a formula this becomes

$$H = 0.000405\ p\ Q \qquad (1)$$

The yearly cost for the power consumed in overcoming the resistance will be the product of this horsepower times the yearly cost per horsepower. The yearly allowance on the cost of the installation for the interest and depreciation may be varied, according to circumstances, the probable limits being 15 to 25 per cent. yearly for any ordinary installation.

*Abstract of paper read before the American Society of Heating and Ventilating Engineers.

Letting C_p represent the total yearly cost of power at the fan and m the cost per horsepower-year, then

$$C_p = 0.000405\ m\ p\ Q = m\ H \qquad (2)$$

Also letting C_s represent the yearly charge for interest and depreciation, based on the cost of the heater, and S the total square feet of surface in the heater, C_s would equal S times the allowance per square foot for interest and depreciation.

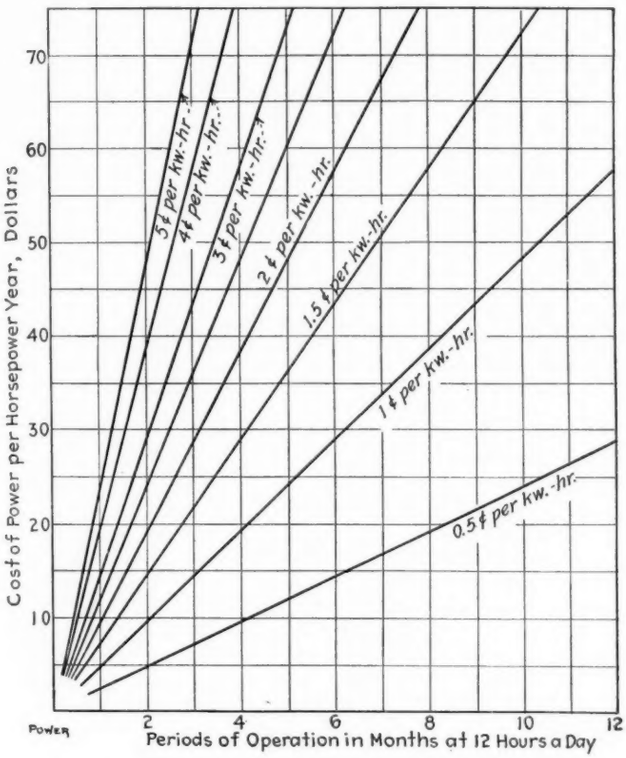


FIG. 1. COST OF POWER PER HORSEPOWER-YEAR

Letting C_{po} and C_{so} be the respective costs at any assumed velocity, V_o, through the clear area, and C_p and C_s be the corresponding costs at any other velocity V, then

$$C_s = C_{so}\left(\frac{V}{V_o}\right)^2 \qquad (3)$$

$$C_p = C_{po}\left(\frac{V}{V_o}\right)^2 \qquad (4)$$

$$\frac{V_m}{V_o} = 0.286\left(\frac{C_{so}}{C_{po}}\right) \qquad (5)$$

$$V_m = 0.66\ V_o\left(\frac{C_{so}}{C_{po}}\right)^{\frac{1}{2}} \qquad (6)$$

If the assumed velocity V is also the most economical velocity, then $V_o = V_m$ and

$$\left(\frac{V_m}{V_o}\right)^3 = 1$$

Assuming then, that the chosen velocity is that which gives maximum economy, equation (5) becomes

$$0.286\,\frac{C_s}{C_p} = 1$$

$$C_p = 0.286\ C_s \qquad (7)$$

This means that for the most economical installation the yearly cost of the power consumed in overcoming the friction of the heater should be 28.6 per cent. of the annual cost of the heater; that is, annual interest and depreciation allowance based on initial costs.

PRACTICAL APPLICATION

As frequent reference will be made to the cost of power per horsepower at the fan, due to forcing the air through the heater against the frictional resistance, Fig. 1 is given to show the relation between this unit and the common one of cost per kilowatt-hour.

Referring to the chart, a plant operating four months a year and twelve hours a day, with power costing 2.5c. per kw.-hr., will be paying $47.50 a year per horsepower. If power costs 1c. per kw.-hr., the horsepower will cost $20 per year. The cost per year, due to the frictional resistance of the heater, may be found by formula (2).

Take, for example, a case where 30,000 cu.ft. of air per min. is to be warmed from zero to 103 deg., by means of a Buffalo pipe-coil heater. Assuming, for convenience, a velocity of 1000 ft. per min., through the clear area, a heater of five sections of 20 rows of pipe deep, with 184.3 sq.ft. of surface per section, will be required. The loss of pressure, due to the frictional resistance, will be 0.48 in. Then

$$Q_o = 30{,}000,\ V_o = 1000,\ S_o = 184.3 \times 5 = 921.5\ sq.ft$$

Operating four months a year at twelve hours a day, the power costing 2c. per kw.-hr., the yearly cost of power will be $40 per horsepower. Then the horsepower required will be

$$H = 30{,}000 \times 0.000405 \times 0.48 = 5.83$$

$$C_{po} = 5.83 \times \$40 = \$233\ a\ year$$

Allowing 15 per cent. on the cost of the installed heater for interest and depreciation on a cost of 35c. per sq.ft.

$$C_{so} = 921.5 \times \$0.0525 = \$48.40\ a\ year$$

Then the maximum economical velocity from equation (6) will be 391 ft. per min.

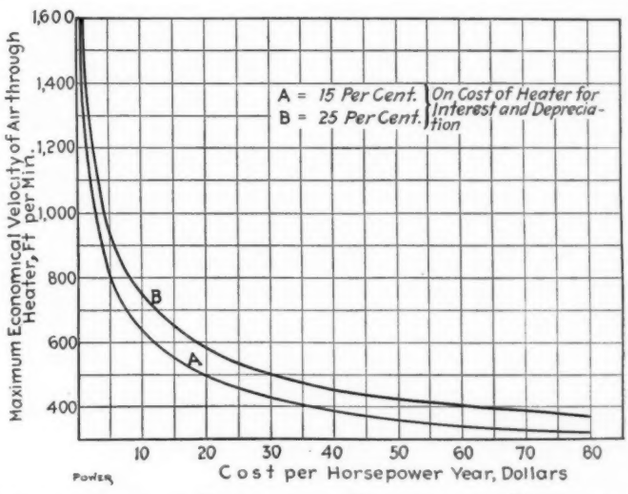


FIG. 2. MAXIMUM ECONOMICAL VELOCITY FOR DIFFERENT COSTS OF POWER

Substituting the various costs per horsepower-year in this formula, the corresponding maximum economical velocity for each case may be determined and the values plotted, as in curve A, Fig. 2.

From curve A, Fig. 2, it may be seen that if a return of 15 per cent. is desired on the investment, in order to use a velocity of 1000 ft. per min., the power should not cost more than $2.50 per horsepower. This would

only be the case where the fan was driven by a steam engine, and the exhaust steam used in the heating coils, practically using the engine for a reducing valve.

Curve *B* shows the same relation of power cost to velocity when 25 per cent. is allowed for interest and depreciation. The curve is similar to *A*, but shows the greater velocity allowable under this condition.

The curves in Figs. 3 and 4 show the general relation between the cost of the power, due to the frictional resistance, through the heater at the two rates of $10 and

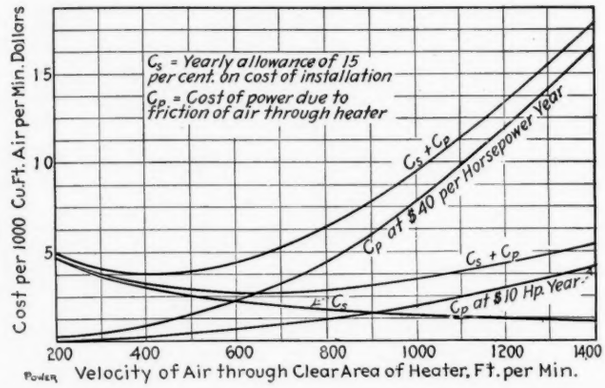


FIG. 3. RELATIVE YEARLY INTEREST AND DEPRECIATION COST ON SURFACE AND POWER COST DUE TO FRICTION OF AIR THROUGH HEATER; ALLOWANCE 15 PER CENT.

$40 per hp.-yr., the interest and depreciation allowance on the cost of the heater and the sum of these two or the total yearly charge. For Fig. 3, an allowance of 15 per cent. is made for interest and depreciation, while for Fig. 4 this allowance is 25 per cent.

The curve $C_s + C_p$ represents the combined cost per 1000 cu.ft. of air per min., due to the interest and power costs for the different velocities. From Fig. 3, it may be

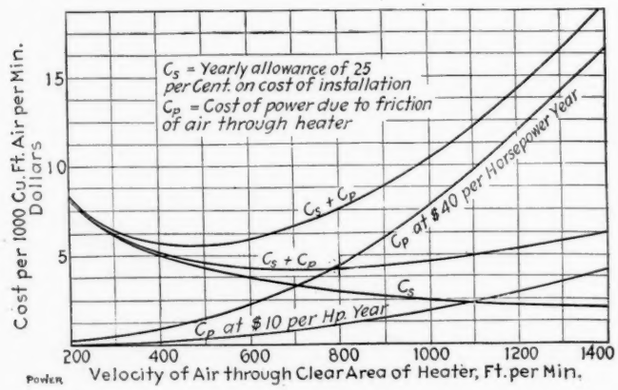


FIG. 4. CHART SIMILAR TO FIG. 3, WITH INTEREST AND DEPRECIATION ALLOWANCE OF 25 PER CENT.

seen that, if power costs $40 per hp.-yr., the lowest total cost of operation will be $3.75 per 1000 cu.ft. per min., at a velocity of 400 ft. per min. through the heater. The velocities at the low points on these total cost curves should correspond to the velocity from the curves in Fig. 2 for the same cost per horsepower-year. The two values of $10 and $40 are taken merely as two representative costs and the curves may be plotted for any other horsepower cost or interest allowance by means of equations (3) and (4).

The assumed values used in making the calculations for Figs. 2 to 4, are not intended to apply in all cases, although they do probably represent average conditions. The price per square foot for the heater installed complete, with casing and steam and drip headers will vary more or less with every case, but 35c. was taken as a fair value and is near enough to most installations to form the basis for a comparative study.

[In the second issue following, the balance of the paper, dealing with pressure losses in the piping system, will be published.—EDITOR.]

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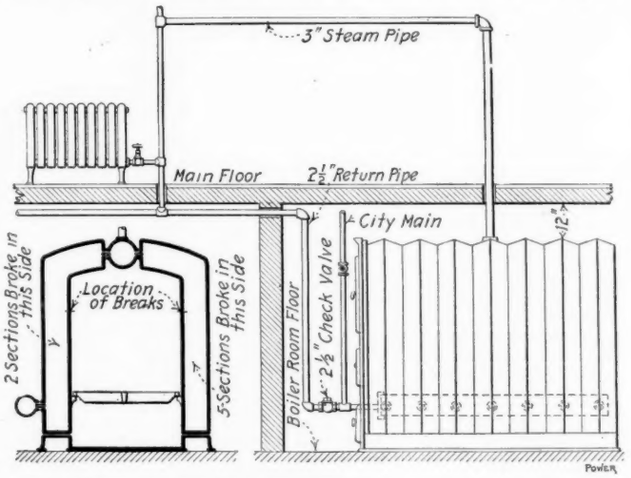
Water Hammer and a Cracked Boiler

A few days before Christmas I went into a new building which was no warmer than outdoors, due to the fact that several sections of a cast-iron boiler had been cracked. The boiler consisted of 14 sections set vertically, seven sections on each side of the fire and coming together at the top, as shown in the accompanying sketch.

Trouble had been experienced in keeping the water in the boiler ever since it was installed. There would be three-quarters of a glass of water in the boiler every morning, but on raising steam it would go up in the radiators and stay there. Water would not show in the glass again



SECTION OF BOILER AND LAYOUT OF PLANT

that day. When pressure began to raise in the boilers the water-hammer in the radiators was so bad that it was necessary to check the fire.

On Dec. 19 it was cold in the building. There was a good fire, but the steam gage stood at zero. One of the men opened the valve on the city water line. There was a hissing in the boiler, so he shut the valve. The hand on the steam gage jumped up to 3 lb., but soon dropped again. He repeated the same operation with the same result. Then he opened the water valve just so that he could hear a little water going through and went to his work. He had just got to work nicely when a peculiar noise was heard in the boiler. Upon investigation it was found that five sections on one side, and two sections on the other side had cracked and were squirting water into the fire. The fire was pulled and the contractor that put in the heating plant was asked for an explanation. It was his opinion that the pipes were too small and it would be necessary to repipe the building.

Duluth, Minn. O. L. SHERMAN.

EDITORIALS

Receiver and Condenser Explosions

The occasional failure, under pressures which they were never intended to carry, of intermediate receivers of steam engines, condensers, etc., suggests a more careful provision against the accumulation in these vessels of the pressure which exists in the boilers to which they are indirectly connected. Some time ago, a receiver exploded because the engineer admitted steam to the high-pressure cylinder with the relief valve open, blowing directly into the exhaust, and, hence, into the receiver. There was, therefore, nearly as much pressure in front as behind the high-pressure piston. The engine would not start, so that there was no relief for the receiver through the low-pressure cylinder and the pressure built up in it until it exploded.

Last month a condenser exploded, with disastrous results, on the French battleship "Messena." The shell of a surface condenser would sustain very little internal pressure. It is ribbed and stayed to withstand external stresses, for the pressure outside is supposed to be greater than that in the interior. Yet, a surface condenser is a closed vessel in more or less direct connection with a steam boiler under pressure. Suppose this connection to be through a steam turbine. It is not inconceivable that, with the unit shut down, sufficient steam might pass through the turbine to create a dangerous pressure in the condenser shell if the discharge through the air pump were obstructed.

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Automatic Appliances for Boilers

That the trend in modern power-plant practice is to eliminate the human element, as far as possible, is clearly indicated by the many devices on the market for the automatic operation and regulation of equipment. As a rule the introduction of any device that will relieve the attendant of some of his many duties, particularly the onerous ones, will make for the better operation of the plant as a whole. This is not necessarily because an automatic device is any better than a man, but because he is able to devote more of his energies to other things, such as planning new methods or economies, etc.

There are two sides, however, to the question of installing automatic devices wherever possible. One of the principle negative contentions is that the adoption of a device, such as a boiler feed-water regulator, for example, will engender carelessness and inattention on the part of the water tender. Those opposing this view argue that any attendant who will become lax and negligent because of some mechanism installed to assist him, is not desirable under any conditions.

However, this is aside from the present intention, which is to call attention to the careful consideration that should be given to the way in which automatic governing and regulating devices and so on are applied and how the connections are made. Sometimes it happens that two or more such devices which control or regulate correlating equipment will so act as to produce opposite rather than similar effects on the apparatus governed. As an illustration, consider first an individual boiler that is self-contained in every respect and that is served by the usual stack, stoker, etc., and operates under forced draft in addition to that produced by the stack. Assume that in the main steam header, or possibly in the goose-neck connecting the boiler and the header, is a nonreturn valve of the type which responds to a drop in steam pressure on either side of it; and that the stack damper, as well as the stoker and fan, are controlled by the usual automatic regulating devices. Suppose these regulators are connected to the steam line between the nonreturn valve and the boiler. If a tube should burst, the drop in pressure would close the valve and open the damper and speed up both fan and stoker. If a break should occur in the steam main beyond the nonreturn valve, the latter would close; consequently the pressure in the boiler would build up, thus closing the damper and slowing down the fan and stoker.

Suppose the regulator connections to the steam line are made on the far side of the nonreturn valve from the boiler. In the event of a tube bursting, the valve closes but the other appliances are not affected, unless it would be after some little time has elapsed in which the pressure in the steam line has fallen off. If a break occurs in the line on the far side of the valve, the latter will close but the damper will open and the air and coal supply will be increased. The only advantage in connecting up this way is that the bursting of a boiler tube is more frequent than the bursting of the steam pipe.

As another illustration, consider a plant containing a number of boilers each equipped with individual nonreturn valves in the goose-necks and only one regulator to control the dampers and one to control the air and coal supply for the entire plant. If these regulators are connected to the main steam header, the bursting of a tube in one of the boilers will simply have the effect of closing the nonreturn valve serving that particular unit; there being no effect whatever on either of the two regulators. If, on the other hand, a break occurs in the steam line, all of the valves will close; the dampers will open; and both the fan and stokers will speed up. To prevent this, the regulator connection should be made to all of the boilers in a small plant or, in a large plant where this is not practicable, to several batteries at points between the boilers and nonreturn valves. This will prevent increasing the air and coal supply when a break occurs in the main steam line and the effect of a tube bursting in one of the boilers will be practically negligible.

From the very nature of these appliances, the functions they are designed to perform and the methods of their operation, it is evident that they work at times to cross purposes. For example, the nonreturn valve is a safety device, designed so that it will close and shut off the steam in case of any unusual happening, whereas the

damper, stoker and fan regulators are intended to control their equipment so as to get uniform operation. The result is that the latter devices will endeavor to maintain a uniform operation under all circumstances and conditions and the more upset these become the harder they will work, even when this is the very thing that is not desired.

Thus it may be seen that the elimination of the so called human element in the boiler house is impossible, no matter how many automatic devices are applied. When everything is running along smoothly there may not be so much required of the attendant in the way of actual and constant attention, nevertheless, when an accident happens or an emergency arises no device so far found is able to take his place.

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The Society for Electrical Development

Since commercial growth is the ultimate aim of all industries this new organization, committeed to the commercial side of electrical engineering, has before it great possibilities. Heretofore, the technical side of electrical engineering has been well taken care of, through a number of representative societies, but the business side has been left largely to individual effort.

The Society for Electrical Development aims to bring together the various interests concerned, such as central stations, electrical manufacturers, architects, contractors, etc., in a sort of mutual aid spirit, and it also proposes through an educational and publicity campaign to greatly extend the use of electricity for industrial and domestic purposes.

In spite of several protestations of public-spirited policies, the program is purely a business proposition and as such is perfectly legitimate. However, it is no secret that the society is to be used incidentally as a weapon by the central-station interests in their war against isolated plants; in fact, several of the speakers at the meeting inferred as much. One of the most effective means of accomplishing this end is the plan for establishing a closer relation between the central station and the architect, builder, and city officials, the central-station engineers to furnish the necessary engineering advice in such problems as may arise. If present practices are to be taken as a criterion, such information will often be strongly biased and we believe the architect and builder should be warned against accepting such information without the most crucial analysis, for in the end the owner is the loser, and the architect and builder are morally responsible to the owner.

Another line of action was suggested in the address of Mr. Doherty who decried the present supervision and regulation of central stations by public-service commissions.

Viewing the question from a strictly independent standpoint, we believe the society has a wide field of usefulness in promoting electrical progress, extending the use of electricity with more efficient application and educating the public as to its possibilities. Insofar as such applications lie within the field of the central station the latter is entitled to all the benefits which it is likely to derive. But where it attempts to further certain mercenary policies under the disguise of more lofty aims and endeavors to use the influence of such a society to hinder or frustrate the efforts of the people to protect themselves through public-service commissions against such extortions and discriminations as have often been witnessed in the past, then the public should become acquainted with the facts and the allied interests, such as manufacturers, architects and builders should be on their guard.

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Efficiency in the Power Plant

The slogan of the day is efficiency. Particularly in engineering lines, there is a marked tendency toward seeking out the sources of waste and as far as possible destroying them. Much has been accomplished, but often too little consideration is given, in the plans of the efficiency expert, to the factor of the operating man. No amount of planning, scientific arranging and organization will bring the desired results unless the man on the job is behind the movement. Tactlessness has often resulted in making an enemy of the operating man where lucid explanation would have made him willing and anxious to coöperate.

In the last analysis the best interests of the owner of a plant and the men who run it for him are identical. An increase in efficiency of one always betters the condition of the other, and the matter of efficiency is really much simpler than might be supposed from reading some of the literature on the subject. Any man is an efficiency expert who keeps his eyes open and first sees where methods are wrong, and then thinks out a way to correct them. The whole secret lies in a habit of mind. Observation and ability to think straight are the necessary qualities.

For example, a man who does a given task daily and grumbles at the excessive labor involved, will probably always be at that job until he is fired. The man who, on the other hand, doing the same work, first wonders *why* it is so hard, then finds out that it might be done an easier way, and finally discovers that easier way, will not be wasted long in that niche—he will be needed higher up.

It is the attitude of mind that counts. Confidence is power, and confidence is bred in accomplishments and knowledge. It is the man who wants to know "why the wheels go round," and perseveres till he finds out, that does things in any line. If the operating man does not get anywhere, the blame never lies in "lack of opportunity," "being tied to a battery of old tea-kettles," or "the boss don't know me." It rests in his own attitude of mind. Get the thinking habit—acquire curiosity—look and ponder—and the rest is just hard work that never killed anyone yet.

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A bill requiring building constructors to be licensed is to be introduced into the New York State Legislature, according to a daily press report. No matter what its merits, we can predict the fate of the bill, for this state hasn't yet got the right perspective on would-be laws that would make for the greater safety of the people. Perhaps, if this bill does pass and the lawmakers can be brought to realize that a collapsing building is not so very much more effective as a life extinguisher than a bursting boiler, there may be some chance of adopting a boiler-inspection law and even an engineers' license law in course of time.

READERS WITH SOMETHING TO SAY

Adjusting Lost Motion in Pump Valves

Setting the valves of a duplex pump is generally considered simple and one of the first things the young engineer is taught, but with pumps in which the valves are set with lost motion it becomes a question to some as to just how much play to allow. A simple rule to follow is to make the combined total lost motion or clearance equal to the width of one steam port. For instance, in Fig. 1, if the width of the port is 7/8 in., the clearance between the lug and the nuts at *C* and *D* should be $\frac{7}{16}$ in. each.

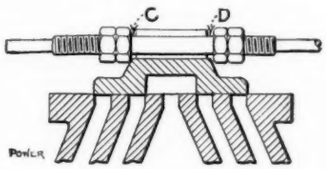

FIG. 1. SHOWING CLEARANCE BETWEEN VALVE STEM NUTS

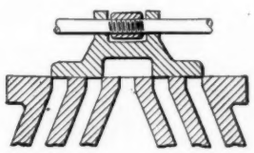

FIG. 2. VALVE STEM WITH ONE NUT

Some types of pumps have a large nut between the jaws of the upper side of the valve, Fig. 2. In this case the clearance is divided and the amount determined by the pump maker. The only advantage in having the clearance adjustable is that sometimes a pump is used with a considerably lower pressure on the water end than that for which it was designed. It is then sometimes necessary to decrease the lost motion which shortens the stroke of the pump, preventing the steam pistons from striking the cylinder heads. This is only the case where the service is very low and the amount of steam used is slight.

JOHN F. HURST.

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The Deadly Monoxide

Carbon monoxide is a product that has no place in a well regulated furnace. Besides the lack of complete combustion attending its formation, it is highly dangerous, when mixed in proper proportions with air, because of its explosive quality. Although at first glance it might seem impossible that the amount of this gas present in the flue could rise to a point where it would be a menace to safety, this very thing has happened. In one instance the fact that the boiler-room man did not realize what an amount of the gas was being formed at times, nearly resulted in a bad explosion.

This plant consisted of a battery of nine horizontal return-tubular boilers arranged in one long row and all connected to a common flue at the back. Two of the nine were very old and to get more work out of them in their old age, steam jet blowers had been installed. All the boilers were hand-fired and all operated under natural draft except the two in question. To prevent leakage around the ashpit doors the latter were sealed tight and the firedoors were a good snug fit. The grates were of the sawdust type with holes not over 3/8-in. in diameter.

The management was considering the purchase of a different brand of coal from that previously used, and before deciding the matter, engaged a testing engineer to run comparative tests on the old and new coal. The engineer ran foul of the boiler-room man at once, as the latter was one of those that believes no outsider can tell him anything about *his* boiler room, but no open rupture occurred.

Along in the second day of the run, the testing man made his hourly Orsat reading and found the percentage of CO had jumped in an hour from one-half of 1 per cent. to *over 14 per cent.* Unable to believe his own figures, he took another sample, renewed his reagents and tested again. This time the result was nearly 15 parts of the deadly monoxide gas.

There being no longer any doubt, the engineer called the head fireman and told him what he had found, explaining the danger. The boss of the boiler room was puzzled and incredulous. He had no explanation to offer because he did not *know* his own boilers and what really happened inside them. Then the testing man thought of the steam-blast boilers and their sealed ashpits. In two jumps he reached the steam valve. Sure enough, it was closed tight and those two boilers were simply generating carbon monoxide, because sufficient air could not reach the fires. It developed then that it was the custom to shut the steam off tight when necessary to clean fires or lay off those two units, and for more than a year this had been going on with an excellent chance each time for an explosion that might have wrecked the plant. That the correct mixture of CO and oxygen had never been attained was pure luck.

When the testing engineer made his discovery it was within 2 per cent. of the danger point. Therefore, the latter laid down a rule that the steam at the blower was always to be turned on, at least the valve cracked, while he was on the job—and reported the matter to the management, and recommended for the safety of the plant that the steam valves in question be arranged so that it would be impossible to quite close them. The general manager of the works, who knew little or nothing of boilers or their operation, was greatly excited and immediately wanted to discharge the whole boiler-room force, but the testing engineer dissuaded him from doing so.

This incident is related to bring out the value of an inquiring habit of mind. If the head fireman had been of the type that thinks for himself, would he have sat complacently over a potential blowup and not found it out? Of course, if the plant had been one where Orsat tests are the usual routine the trouble would have been found at once, but without any testing apparatus an efficient boiler-room man would have made all the more sure that the battery was in proper shape. Such a man

would have stopped to reason, just as soon as the steam jets went in—"How is this going to effect combustion?" He would have considered the sealed ashpits, the lack of air without the blower and concluded that shutting off the latter simply turned his boilers into gas producers. This man did not think and nearly lost his job, if not his life, in consequence. There is no doubt that many disastrous steam explosions of boilers have been caused primarily by a CO explosion which throws the boiler off its setting and breaks the steam connections, and the percentage of CO would never have reached the danger point if the man in charge understood the character of this gas and the conditions under which it is formed. Give a fire air enough and there is no chance of trouble.

H. R. Callaway.

New York City.

Power Pump Troubles

Many times troubles develop in power pumps which are difficult to locate. Probably the greatest source of trouble is in the valves, which become worn and uneven, and if they turn slightly on the stem the port opening is not properly closed and excessive slip results. Other causes of valve trouble are sticks, leaves and rubbish clogging the seats or blocking up the valves. Valve stems sometimes work loose and drop out and the valves that do not fit properly become wedged or stuck.

Sometimes difficulty is experienced in lifting water by suction, which may be due to various causes. The pump and the suction line should be well primed before starting and for long or high suction lifts a foot valve of a large valve area should be provided.

All air pockets should be carefully avoided in the suction line, and pumps which are so designed as to form air pockets in the suction-valve chamber should be avoided. Plunger or piston and piston-rod packing should be of good quality and properly installed. In installing a pump it should not be forgotten that pipe friction is to be overcome in the suction as well as in the discharge line; therefore the pipe lines should be kept free from sharp bends.

Air in the suction line will cause pounding. Hence all leaks should be repaired and it should be seen that the suction pipe is properly submerged at the intake.

Long suction lines will sometimes knock from the momentum of the column of water which must be started and stopped. A suction or vacuum chamber to cushion the shock will remedy the trouble. Hot water will evaporate in a vacuum and cause a severe knock if lifted by suction. Therefore, the water should be brought to the pump under a slight head if possible.

As worn crank- or pinion-shaft bearings will vary the shaft centers and cause noisy gears, the gearing should be properly lined up and the centers properly adjusted and the bearings rebabbitted. Cast gears may have one or two large teeth in the gear or pinion which will cause a noise at each revolution. Filing down to a proper size will remove the noise.

Single pumps, and even duplex and triplex pumps, will occasionally develop pounding in the discharge line. The cause may be a fluctuating discharge, which may be remedied by a discharge air chamber, proper care being taken that it is supplied with air. Faulty check valves in the discharge line, improper arrangement of piping or frequent opening and closing of the discharge valves may cause knocks.

Every power pump should be fitted with one or more relief valves placed close to the pump to prevent breakage. A check valve in the discharge line will take the load from the pump-discharge valves during a shutdown.

G. H. Bridges.

Holyoke, Mass.

Experience with Water Softening Plants

In the hope of getting engineers to tell of their experience with water-softening plants, I submit the following:

My first experience was with feed water, taken from a well, the hardness of which, by Dr. Clark's soap test, was 34 deg. About 20 deg. of this hardness was temporary, the remaining 14 deg. being permanent. The hardness was due to carbonate and sulphate of lime with a little magnesia, and varied with the season, rainfall and melting snow in the hills, causing a variation of 4 or 5 deg. We made a rough test of the water daily as follows:

Seventy c.c. of the well water was tested with the soap solution and the total hardness noted. At the same time a quantity of the well water was subjected to prolonged boiling. Carbonate of lime is insoluble in water and can only be held in solution in the form of bi-carbonate. Boiling liberates the carbonic acid and the bi-carbonate then becomes carbonate and is precipitated. After cooling, 70 c.c. of the boiled water was tested with the soap solution and the hardness noted as permanent hardness, the difference between this and the total hardness previously noted being the temporary hardness.

To estimate the magnesia, about a liter of well water was treated with a gram of ammonium oxalate. This precipitated all the lime and after filtration 70 c.c. of this water was subjected to the soap test and any hardness above 1 deg. was multiplied by the fraction $^{42}/_{75}$, the result giving, approximately, the hardness due to the magnesia. These tests are rough and such as any engineer can make. They enable him to discover if there is any radical change in the water.

The plant we had for treating this water was designed to remove the temporary hardness only, and was worked on the Clark system. By this method, caustic lime is added to the water. This neutralizes the excess CO_2, and by so doing the lime originally in solution and the caustic lime are precipitated as carbonates. The capacity of the plant was 12,000 gal. per hour and the arrangement was as follows:

The water from the well was pumped to a mixer where it received the requisite amount of caustic lime. From the mixer it passed to a settling tank where precipitation took place; the water, turbid with lime, entering at one end and flowing over a weir at the other end, comparatively clear, to the filters. After passing through the filtering medium, which in this case was sail cloth, the water passed to the storage tank.

This plant worked fairly well, the temporary hardness being reduced 17 deg. If, however, the plant was worked to its full capacity there was likelihood of trouble through the softening process being continued in the pipes, tanks, etc., beyond the filters, carbonate of lime

being deposited in places where it should not be. The filters were also likely to give trouble. As the filtration was through one ply of sail cloth only, if a hole developed, free lime entered the piping, etc., and was precipitated therein. Had there been double filtration there would have been less chance for unfiltered water to enter the piping.

Although these defects were against the plant, there was a great reduction in the hardness of the water, practically the whole of the carbonates, together with a part of the magnesia, being removed. The softened water was also free from organic contamination.

The next plant I had charge of was designed to remove both the temporary and permanent hardness from a similar water to that treated in the first plant. The makers of the apparatus promised a reduction of 29 deg. in the hardness by means of the lime-soda process. In this plant, which had a capacity of 20,000 gal. per hr., the water was pumped to a mixer, where it was automatically mixed with the right amount of soda and caustic lime. The water and chemicals then passed to a settling chamber where most of the precipitation took place, and from thence through three wood wool filters in series, to the storage tanks.

This system had triple filtration as against the single filters of the first plant, and, although the water remained for several days in the storage tanks, there was no precipitation therein. This showed that there was no subsequent softening action going on after the water had passed through the plant, and that no sediment was passing the filters.

We could reduce to 4 deg. hardness quite easily, but our experience showed us that for boiler feeding, pitting of the plates was likely to happen by getting the water down to a minimum hardness. We found that it was better to work at 7 deg., as a slight excess of soda in the water caused foaming with all the bother at the engine that foaming causes. This plant gave excellent results and our boilers greatly benefited thereby.

We had water-tube boilers and it was quite a common thing to shut down for bagged and leaky tubes. As many as ten tubes have had to be removed in a day prior to installing the softening plant, and now this trouble has practically ceased.

My next experience was with with a plant for dealing with quite a different water, the hardness of which was 14 deg., 9 deg. being permanent and 5 deg. temporary. This water was obtained from a source little better than a sewer and there was much solid matter in suspension apart from the hardness. It was originally intended that this water should be simply filtered and freed from organic impurities and no provision was made for reducing the hardness appreciably. The process was as follows:

Pumps drew from the water supply and chemical tanks, and delivered from a closed, vertical cylindrical tank, the outlet of which was connected to pressure sand filters. In the chemical tanks was a solution of aluminum sulphate and a valve in this tank was so regulated that a sufficient quantity of the reagent was drawn into the pump along with the untreated water.

This reagent assisted the purification in two ways. It caused the suspended matter to coagulate and be precipitated in the settling tank, and, secondly, an insoluble gelatinous substance was formed in the filters, which materially assisted filtration and was capable of destroying micro-organisms and extracting coloring matter. The water left the filters remarkably clear and free from impurities other than the lime and magnesia salts in solution.

To eliminate these salts and thereby soften the water, a chemical pump was installed, which was actuated by the main pump, and which drew liquid from another tank containing a lime-soda mixture. The capacity of this pump was such that a close approximation to the correct amount of reagent was mixed with the water on the delivery side of the main pump, finer adjustments being made by varying the strength of the solution. From this point the process was the same as it was prior to the adoption of the softening apparatus. With the addition of the lime-soda, a reduced amount of aluminum sulphate is required. The main pumps are of the duplex type, and the advantage of having the chemical pump driven by the duplex pump is that any variation in the length or number of strokes causes a like variation in the speed of the chemical pump, thereby maintaining the correct ratio between the amount of water and reagent.

The plant is capable of handling about 50,000 gal. per hr.

Any person who has seen the sludge taken from a softening plant, treating only moderately hard water, will be convinced that the heater and boiler are not the best places to soften feed water.

For boiler feeding, it is not advisable to soften the water to the lowest possible limit when working with the lime-soda process, or there may be trouble from foaming. It is better to have a margin of 2 deg. or thereabouts.

MAC DICKMAN.

Paisley, Scotland.

Putting in a New Piston

A quick way of putting in a new piston and rod is as follows:

Get a straight stick 1½ in. wide and 8 in. longer than the cylinder. Then measure the inside length of the cylinder, from the crank-end head to the outside edge of the head end, graduating the stick in inches with a thin knife blade and square. If the length of the stroke is 48 in., measure off 48 in. on the stick from the end.

Then measure the thickness of the piston and mark off this measurement on the stick from the stroke measurement, which would be the length of stroke plus the thickness of piston. Next measure the thickness of the cylinder head from the flange with the gasket in place. This will leave but very little space on the stick measurement of the length of cylinder, say $\frac{5}{16}$ in., which is the total clearance for both ends of the cylinder, or $\frac{5}{32}$-in. clearance for each end between the piston and each head.

Then place the engine on the head-end dead center, and screw the piston rod into the crosshead until the piston is in the cylinder from the outside edge a distance equal to the thickness of the cylinder head, plus the clearance, $\frac{5}{32}$ in. Then tighten up the crosshead nut on the piston rod, secure the cylinder head and if the measurements have been correctly made the piston has equal clearance at each end of the cylinder.

A. I. HAIGHT.

Kalamazoo, Mich.

QUESTIONS BEFORE THE HOUSE

Logical Unit of Power

Replying to Mr. Liddell's letter in the Feb. 4 issue, on the "Logical Unit of Power," I would say that, in the ultimate analysis, the ampere is determined electrolytically—not by an ampere balance. However, both the ampere and the ohm, as determined fundamentally in a standard laboratory, are based on gravity, as are all other units representing or contributing to work, excepting those of space. But the instruments used universally for indicating amperes and ohms and watts, give the same indications everywhere, whereas the common pound and ounce weights have not the same absolute values at all latitudes.

If ammeters and wattmeters were all made with retractile weights instead of springs, the relation between electrical and mechanical measurements would be the same at all points. When I said that the kilowatt is the same everywhere within man's reach, I meant the kilowatt as universally measured, not as derived from original determinations made at Washington or Paris.

The question whether the kilowatt can be measured more closely than the mechanical equivalent is irrelevant; also whether the operating engineer uses 746 or 745.6 watts as the electrical equivalent. Undoubtedly, both 746 watts and 550 ft.-lb. per sec. will always be used as horsepower equivalents in ordinary everyday work, but that has nothing whatever to do with the question of whether it is more expedient in scientific work to take 746 as the exact equivalent and let the foot-pound values wabble, or *vice versa*.

C. P. Poole.

Atlanta, Ga.

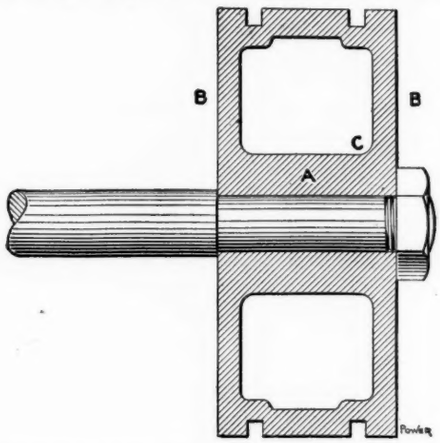
Cause of Piston Fracture

In the Nov. 5 issue, H. R. Rockwell relates his experience with fractured pistons on a 12x12-in. duplex single-stage air compressor, working against 100 lb. receiver pressure. Three of these pistons fractured one after another, and Mr. Rockwell asked what was the cause of the trouble.

I believe the initial cause of the failure of the pistons was their weak design. By referring to Mr. Rockwell's illustration of one of the fractured pistons, it may be seen that all the corners on the inside of the piston are square and sharp. This is a feature that should be avoided when possible in machine design.

The action of the iron in such shapes when poured and cooled at the foundry would be to pull the hub from the piston because the sand of the core which forms the shape of the inside of the piston, will keep the hub *A* hot after the faces *B* have cooled off and later when the hub *A* cools, there will be a severe shrinkage strain at the point *C*, where the hub joins the inner side of the piston. If the interior of the piston had been shaped like that shown herewith, having fillets instead of sharp corners, the castings would have had sufficient strength to resist the shrinkage strain because with rounded corners there would be no points from which a fracture could start. This is on the same principle as drilling a hole in a boiler plate at the end of a crack or fracture to prevent an increase of the length of the crack.

The force that actuates the compressor piston is transmitted to it by the piston rod. The resistance to be overcome in this instance is about 11,300 lb., which tends to push and pull the middle out of the piston which intermittent action will soon cause a piston to fail, as described by Mr. Rockwell.



Piston with Rounded Inner Corners

J. W. Parker.

Clinton, Mass.

In reply to H. R. Rockwell's request, regarding the piston troubles he has had with his air compressor, I think his trouble was due to presence of oil in the piston. The heat of compression caused the oil to vaporize or gasify, and later on, during the ordinary operation of the compressor, the heat of compression became great enough to ignite this gas or vapor, and caused an explosion of the piston. As he has adopted the use of a solid piston he will not have this trouble again, but if he continues to use the same oil, and if not very cautious, it may result in the explosion of a cylinder or pipeline.

E. H. Hart.

Baskett, Ky.

Although I cannot offer any solution as to the cause of the piston fracture, described by Mr. Rockwell, it recalls an experience of mine with a similar trouble. I was employed as foreman in a shop which made a specialty of making horizontal cross-compound engines. We also did much work in millwrighting and general repairs. One morning we received an urgent call from a mill in a neighboring town, requesting us to send a man over immediately, as the engine was completely wrecked.

On arriving at the plant I found the high-pressure cylinder had been badly damaged. The back cover of the

cylinder lay against the wall. The words of Mr. Rockwell accurately described the condition of the piston, "nothing was left on the rod except the hub or eye through which the rod passed," and the piston rod and connecting-rod were both badly buckled. Finding that the low-pressure side was intact and in good condition, I first set about getting this engine running, which carried the greatest part of the load.

On going back to the wrecked or high-pressure side, it was soon apparent to me that the trouble was brought about by the connecting-rod cotter (key) working out and I explained to the mill manager that my experience was that sufficient warning by knocking or bumping was usually given in circumstances of this kind, to allow of shutting down the engine before any serious damage could be done. In reply to my inquiry as to where the engineer was when the accident happened, the manager replied, "At the other side of that field," pointing to a field about 600 yards away. Evidently the engineer made a hurried exit from the plant as soon as he heard a slight knocking in the cylinder.

F. P. STRACHAN.

Belfast, Ireland.

Dalton's Law in the Steam Plant

The letter by Louis Grossbaum, published in the Feb. 4 issue of POWER, commenting upon my previous article on "Dalton's Law in the Steam Plant," is of interest, because his statements are correct, but at the same time they do not contradict any of the statements in my previous article. His letter does serve to show how loosely many engineering terms are used.

Mr. Grossbaum discusses the flash point of oil purely from an academic standpoint and assumes it is used for determining *the temperature at which explosive mixtures of oil vapor with air are formed.* While this is a physical fact, engineers use "flash point" for determining the volatility of cylinder oil, and this is what I had in mind. That is, the flash point was considered merely as a measure of the temperature at which a certain rate of evaporation would occur from the surface of oil. With this qualification in mind it is evident that none of the remarks are misleading. The statement that the same flash point would exist under 150 lb. air pressure was perhaps unfortunate, but I was merely using air as an example of another gas in contradistinction to 150 lb. steam pressure. I might have said 150 lb. pressure of carbon-dioxide gas (a nonsupporter of combustion) and from an engineering standpoint the oil would still have a flash point the same as it does with steam, although as Mr. Grossbaum points out, in the latter case it would be impossible to obtain a physical flash.

Engineers in this country use flash point to tell them whether or not, when they inject a drop of oil into a cylinderful of steam at a given temperature, it will immediately flash into a vapor or will maintain its liquid state and have some value as a lubricant.

It might also be well to point out here that with a large body of oil in a cylinderful of steam it would be possible for enough of this oil to evaporate to build up a pressure of its own vapor so that the flash point might be raised, but when it is considered that under ordinary circumstances only a minute drop of oil mixes with a cylinderful of steam, it is seen to be practically impossible for so small an amount of oil to build up an appreciable pressure of its own vapor.

I am still sure that the author of the book referred to in the original article was laboring under a delusion and was not familiar with the practical application of Dalton's Law. For in speaking of the fact that 150 lb. steam pressure raises the flash point he says: "This will explain why it might be possible to use a cylinder oil successfully for lubrication under superheated-steam conditions where the temperature of the steam might even be a good deal higher than the flash point of the oil measured under atmospheric conditions."

In other words, he would have us believe that the steam pressure would tend to raise the flash point and thus hold the oil in its liquid state in spite of the high superheat. It is this fallacy that I wished to combat, for, as I pointed out in the article, the steam (another gas) pressure is not going to raise the flash point. So let no engineer delude himself into believing he can use a cylinder oil of low flash point and expect the steam pressure to hold the oil in its liquid state.

It might not be amiss to mention at this point that if engineers are going to use the term flash point, they should, in order that they have an absolute basis of comparison, state under what atmospheric conditions the test was made, that is, barometric pressure, humidity, velocity and temperature of the air in the rooms, etc., for, of course, if there were a strong current of air passing over the oil under test, a large proportion of the vapor would be carried away and it would be impossible to get a mixture rich enough in ignitable vapors to give a flash.

The importance of these variables is now appreciated by chemists and engineers who make a specialty of oil testing, for whereas the "open flash test" was formerly accepted, the "closed flash test" is now considered more reliable and apparatus has now been perfected for controlling and measuring the extraneous variables that affect the flash point.

It is interesting to note that the use of "flash point" as a measure of volatility is only roughly correct as has been proved by recent experiments. Archbutt has perfected an instrument known as a vaporimeter for determining the loss in weight of oil at any given temperature. The principle consists in passing a known quantity of air or steam at a known temperature over a given weight of oil and determining the rate of evaporation by noting the loss in weight of oil. He determined the following relations between volatility and flash point.

	Sp. Gr. at 60 deg. F.	Flash Point,* deg. F.	Loss Wt. in 1 hr. at 370 deg. F. in 2 liters per min. Per cent.
American cylinder oil.....	0.902	585	0.12
American cylinder oil.....	0.898	512	0.55
American cylinder oil.....	0.893	424	4.18

*Tests made on a Pensky-Martens instrument, closed "flash test" apparatus.

This shows that the use of "flash point" for measuring the volatility is probably close enough for practical purposes, but that no known simple relation exists between the two. Might it not be well for engineers to cease using the term "flash point" as a measure of the suitability of any given oil for use in steam-engine cylinders under various degrees of pressure and superheat, and to adopt some more rational standard based upon the rate of evaporation under standard conditions?

New York City. GEORGE F. FENNO.

Feed Water Heating and Pumping

The discussion of the pumping problems in the article, under the above title, appearing Feb. 4, is not in accordance with present and coming American practice. We differ at present in that the single pump is not the accepted standard and in that the turbo- and electric-driven centrifugal pumps are replacing reciprocating units in a large number of the modern installations.

The preference for single or duplex pumps is largely a matter of individual taste. The single pump offers as advantages: fewer boxes and glands, full stroke and lower steam consumption, outside adjustment of valves.

For its advantages, the duplex pump offers: positive action, less operating trouble as practically two pumps are provided, steadier flow to boilers, thus permitting higher speeds without jar to the boilers, and less space occupied.

For the centrifugal pump used aboard ship, the regulation is the main problem. If electric power is obtainable, it may be used. However, it is preferable to drive boiler feeders here by the same source of power that actuates the main machinery. Steam turbines have been perfected that will regulate within boiler pressures from 25 per cent. below to 15 per cent. or more above standard conditions. Further, the steam turbines are used largely on land and could be used to advantage for marine work.

In present plants, where boiler feed is being satisfactorily handled by single or duplex pumps, it may be all right to accept the old situation. However, every new plant should seriously consider both types of machinery. The low first cost will protect the reciprocating pump on plants below 1000 boiler horsepower, as the steam saving effected would hardly offset the first cost. As an example, take a plant of 750 boiler horsepower operating under 100 lb. steam pressure.

A duplex pump would have 8-in. steam cylinders, 5-in. water cylinders, 10-in. stroke, and would deliver some 55,000 lb. of water per hr. at a piston speed of some 30 ft. per min. This pump would cost around $200 and, operating at this slow speed, should last indefinitely with replacements of valves and gaskets. The steam consumption would be at least 150 lb. per hp.-hr., or 639 lb. per hr.

This same boiler could be fed by a 2-in. two-stage centrifugal pump direct connected to a steam turbine operating at 2600 r.p.m. The pump and turbine would cost about $600 and would require not over 450 lb. of steam per hour, or a saving of 169 lb. per hr. over the reciprocating unit.

An electric-driven centrifugal pump would cost about $500 and would require but 300 lb. of steam per hour under the worst conditions. Both of the centrifugal installations would be good for boilers with double the capacity. Here, it will be seen that the first costs approach, while the saving effected in steam consumption increases directly as the horsepower of the boilers.

Large users of power all over this country are meeting the new conditions and accepting the improved machinery. Steam reciprocating units are being replaced by centrifugal units. First cost once out of the way, as is the case where the capacity of the plant is above 1000 boiler horsepower, the new pumps speak for themselves.

The saving in steam consumption amounts to about 50 per cent. and the complete unit requires much less room. It further means that the flow to the boilers is smoother and without the shock to the piping and boiler tubes obtained when reciprocating pumps are used. A final saving seldom considered, is the fact that the exhaust from the steam turbines is free from lubricating oil, which means purer water to the boilers.

The reciprocating pump will continue to be used where the capacity desired is small or where the head for discharge is excessive. The centrifugal pump costs more, but the saving effected by its use will more than counterbalance this disadvantage.

F. C. Wight.

Dayton, Ohio.

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World Beating Discoveries

In the Feb. 11 issue, under the title "World Beating Discoveries," I fear that Mr. Booth has given a grain of comfort to the promoters of the scheme for the centrifugal separation of carbon dioxide from its associate gases. That the scheme is not impossible but only impracticable may be the stand taken by these gentlemen.

The inference from Mr. Booth's article is that a well insulated vessel containing a mixture of gases should show a greater percentage of the heavier gases at the bottom. This I do not believe, because if the kinetic theory of gases is correct, the only restraints on the movements of the molecules of the gases would be a reduction of temperature and the sides of the vessel. This in the case of a mixture would affect all of the gases composing the mixture and we would still have the intimate mingling caused by diffusion.

Does not the phenomenon known as diffusion (the power of which is illustrated by an example in Mr. Booth's article) preclude the possibility of a separation by the action of gravity?

It seems to me that as long as there is heat enough to maintain the gases in a gaseous state, there will be more or less perfect diffusion and that separation must be effected by means other than gravity.

Kansas City, Mo. C. O. Sandstrom.

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Evaporative Test of Cylinder Oil

C. E. Fairbanks, in the Jan. 7 issue, describes a method of testing cylinder oil by evaporating it from an ordinary blotter, which gave just the reverse results from our experiments with cylinder lubricants.

Some months ago, we were sent a 5-gal. can of a new cylinder oil to try. It was also guaranteed that only one-half as much of the new oil would have to be used as of the old. In the afternoon of the first day we began using the new oil we experienced trouble, for we could not get enough of the new oil through the lubricator to lubricate the cylinder walls, valve seats and piston rod.

The test we made of the oil, both the new and the old, was practically the same as that made by Mr. Fairbanks and, as related in his letter, the new oil showing the same as that of No. 2, and the old oil showing up just a little better than No. 6 of the photographs submitted by Mr. Fairbanks in the Jan. 7 issue. Our boiler pressure is 140 lb. gage; the engine is a 20x48-in. Corliss.

Fort Madison, Iowa. Thomas C. Robinson.

INQUIRIES OF GENERAL INTEREST

Solid vs. Built-Up Piston—Why is a solid piston preferred to a built-up piston in a high-speed engine?

C. E. A.

At a high speed of rotation and frequent reversing, there is more danger with a built-up piston that parts may become separated and do damage.

Feed Water Temperature—How hot is it possible to get feed water in an open heater?

G. W. D.

Water in an open heater, i.e., one in which the water is under only atmospheric pressure, cannot be heated to above 212 deg. F., as further heat passes off in evaporation as fast as it is added.

Bleeder—What is a bleeder?

A. W. C.

A bleeder, or a bleeder connection, is a connection from a steam pipe or other vessel for drawing off water of condensation. Many apply the name to only such connections as draw off water when a valve or trap is opened by hand, and give the name "relief" to any automatic draining arrangement.

Feeding Water Hotter than 212 Deg.—Will a pump deliver water into a boiler at above 212 deg. F. If so, how much?

D. W. G.

A pump will discharge water into a boiler at 212 deg. F., or any higher temperature, if the water is supplied to the pump under a pressure corresponding to the temperature. Otherwise, vapor will form in the pump cylinder, preventing the cylinder from becoming completely filled with water.

Cylinder Counterbore—What purpose does the counterbore in the ends of a cylinder serve?

W. E. S.

The counterbore prevents a shoulder or rounded end being worn where the rings stop rubbing when the piston reverses its stroke. With the counterbore, part of the ring "wipes over," so that the actual rubbing surface of the cylinder wears uniformly lengthwise.

Power to Compress Air—Which will take the more power, to compress a given amount of air to a given pressure isothermally or adiabatically?

A. E. J.

More power will be required to compress it adiabatically as may be seen by reference to the diagram given on page 507 of the Oct. 1, 1912 issue. The area of the isothermal diagram, and hence the amount of work, is less than that of either the actual compression or the adiabatic diagram.

Ventilating a Boiler Room—How can the gases and fumes from a boiler room, where a low grade of culm is burned, be removed? A roof ventilator seems to be ineffective; why is it?

W. S. C.

If there are not doors or windows on opposite sides of the room which can be opened to create cross-current ventilation, it will be well to install an exhaust fan near the floor. Overhead ventilation is ineffective because the gases, as they cool, settle, being heavier than the surrounding atmosphere.

Removing Oil from Belting—How can oil be removed from leather belting?

A. C. H.

No solution or wash should be used for removing oil from belting as it would be likely to loosen the cemented joints. It is safer to apply a powder such as whiting, fuller's earth or carbonate of magnesia to take up the oil. Afterward the oil may be washed out of the powder with a strong alkaline solution and, after settling, the solution may be drained off and the powder dried and repulverized for future use.

Volumetric Efficiency—What is the volumetric efficiency of an air compressor and how is it obtained?

J. E. A.

The volumetric efficiency is the ratio of the volume of free air actually compressed in a given time to the piston displacement in the same time. To determine it accurately, the only way is to measure the air taken in or discharged, or both, as a check, since there are several variables entering in. Approximate determinations may be made from indicator cards, as explained on pages 963 to 965 of "Experimental Engineering," by Professors R. C. Carpenter and H. Diederichs, (1912 edition).

Effect of Increased Exciting Current—Will increasing the exciting current on an alternating-current generator increase or decrease the lead of a wattless current?

E. J. R.

It will not increase or decrease the lead or lag of a wattless current. However, the voltage drop, at full load, is greater with a low-power factor, and the lower the power factor the poorer the voltage regulation in an alternating-current machine. From this it will be seen that with a low-power factor, the field current of the machine must be increased to carry the load at the required voltage. However, the regulation of the field current has no direct effect upon the power factor. This is governed entirely by the character of the load. If synchronous motors form part of the load, by regulating the field current of the motor, it may be made to take a larger leading wattless component, and thereby raise the power factor of the system.

Dutch-Oven Furnace—Where did the Dutch-oven furnace originate? What kind of fuel is used in it? Is it economical in the use of fuel? Does not a furnace directly under a boiler give better results where wood and refuse are burned?

E. G. H.

The "Dutch-oven" type is a very old form of furnace used for heating long cylindrical boilers, laid down close to the ground with very low side walls and frequently a long ditch-like passage for conveying the products of combustion beneath the boiler. Some of the earliest of these furnaces so used were employed by blast furnaces in the United States, burning coal or wood and later waste blast-furnace gases.

Properly designed and proportioned, a Dutch-oven furnace can be operated more economically than a furnace placed under one end of a boiler. The waste of heat by radiation from the roof is usually more than offset by the more complete combustion not so generally attainable in an ordinary furnace wherein the gases are too soon chilled by the boiler surfaces. This applies regardless of the fuel used.

Horsepower of Tubular Boiler—What is the horsepower of a return-tubular boiler having a shell 4 ft. in diameter, 18 ft. long with 24 four-inch tubes?

W. L. K.

The usual rating of such a boiler is based on 10 sq.ft. of heating surface per boiler horsepower. The rule for finding the heating surface is to add one-half the area of the shell, the internal area of all the tubes and the area of one head minus twice the area of one end of all the tubes. In this case one-half the area of the shell is

$$\frac{3.1416 \times 4 \times 18}{2} = 113.1 \text{ sq.ft.}$$

The internal diameter of a 4-in. tube being 3.732 in., the internal area of the tubes is

$$\frac{3.1416 \times 3.732 \times 18 \times 24}{12} = 422.06 \text{ sq.ft.}$$

The area of one head is

$$4 \times 4 \times 0.7854 = 12.57 \text{ sq.ft.}$$

Twice the area of one end of all the tubes is

$$\frac{2 \times 4 \times 4 \times 0.7854 \times 24}{144} = 4.19 \text{ sq.ft.}$$

The total heating surface, therefore, is

$$113.1 + 422.06 + 12.57 - 4.19 = 543.54 \text{ sq.ft.,}$$

and the horsepower, according to the above rating

$$\frac{543.54}{10} = 54.35 \text{ hp.}$$

The total horsepower which can be got out of the boiler will exceed this, for it is limited only by the amount of heat that can be put into the boiler. All boilers can be forced considerably beyond their normal rating.

ENGINEERS' STUDY COURSE

MENSURATION—PART VI

SPHERES

A sphere, Fig. 1, is a solid having a curved surface all points on which are equally distant from a point within called the center.

A very easily remembered formula for the area of the surface of a sphere is

$$A = 4 \pi r^2$$

where

r = Radius;

$\pi = 3.1416$.

When it is remembered that the area of a circle is equal to πr^2, it will be seen that the area of a sphere is four times the area of its cross-section through the center. For a mental picture, to fix the fact in the mind, imagine an orange quartered by two cuts at right angles; then the area of the skin surface of the quarter section will exactly equal the sum of the areas of the cut surfaces.

To prove the formula for a sphere's surface, suppose a section of a sphere, similar to the quarter orange section to be cut as shown in perspective in Fig. 2. It is now an eighth of a sphere, but for the purpose of our proof, we will slice off a little more, as indicated, until the distance around the circumference is just equal to the radius r.

In Fig. 2 this piece of a sphere is also shown as in a working drawing—three views—one directly toward the curved surface (which by the way is called a spherical

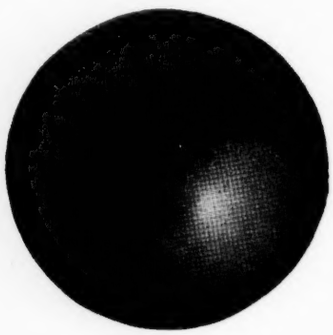


FIG. 1.

triangle), as the piece stands on its flat base, one a view looking directly down on it, and one a sectional side view. The distance ABC is the actual altitude of the spherical triangle. Let this be divided into equal parts, and the object sliced as indicated by the horizontal lines. By construction, the base of the triangle was made equal to r, therefore, any other of the horizontal curved lines as r' will be equal in length when straightened out to the corresponding horizontal lines in the right view, which lines, it will be observed, grow gradually shorter and closer together going from the bottom to the top.

Presuming these slices to have been made very thin, instead of as drawn, and the area of one at the bottom, as *abcda*, would be equal to the height as measured along the curved altitude multiplied by the radius and its equivalent flat area would be found at *AefgA* in the right view. But, proceeding upward, this is no longer true. For example, at r', the unit altitude is still the same for the actual area, but in the right view is becoming shorter; hence, to show true area, we should have to draw a new figure as *hijkh*, in which *hk* is equal to *hl* or r'. Suppose we draw a perpendicular from *i* to the line *hl*, as *im*. As

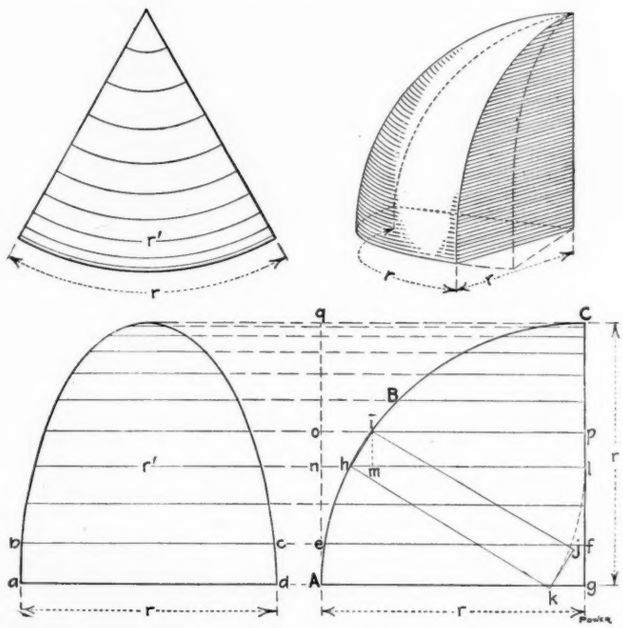


FIG. 2.

can be seen by inspection, *im* is shorter than *hi* and, if we wanted to construct a rectangle equal in area to *hijkh*, with the altitude equal to *im*, it would have to have a base longer than *hk*. By actual measurement, we would find that it must be *nl*, which proves to be equal to r, and the area *nopln*, being made equal to the area *hijkh*, also equals the corresponding curved area having r' as its base.

So it might be shown for any other small area slice clear to the top and the sum of all these areas will be the spherical triangle in the one case and the square $AqCgA$ in the other, which must, therefore, be equal.

The area of the square we know is $r \times r = r^2$, then the area of our triangle is r^2 and it remains only to discover what part this spherical triangle is of the sphere's total surface.

Since the base equals r, to complete a half sphere made of such pieces would take as many pieces as r is contained in the circumference, or

$$\frac{2 \pi r}{r} = 2 \pi \text{ pieces}$$

To make a whole sphere, would require twice as many

or $4\ \pi$ pieces, and each piece being of area r^2, the whole sphere's area is $4\ \pi\ r^2$, as was to be proved.

Another interesting thing that is true of the area of a sphere is that it is exactly equal to the convex area of a cylinder that will just contain it, as in Fig. 3. (By convex area it will be remembered is meant the curved area of the cylinder or the total area minus the areas of the two circular ends.)

Let us see why the above statement is true. We have seen that the area of a sphere equals four times the area of a circle formed when the sphere is cut through its center (such a circle is known as a *great circle*). Expressed as a formula, this was,

$$A = 4\ \pi\ r^2$$

Suppose we divide this by the diameter, D, or, what is the same thing, twice the radius, $2r$, we then have

$$\frac{4\ \pi\ r^2}{2\ r} = 2\ \pi\ r$$

but, as we learned before, $2\ \pi\ r$ equals the circumference of a circle of radius r, i.e., a great circle.

Then another way to find the surface of a sphere is to multiply its diameter by the circumference of its great circle. To find the convex area of a cylinder, as explained in an earlier lesson, we would multiply its height by its circumference. But by inspection of Fig. 3, we will see that the cylinder's height, in this case, equals the diameter of the sphere and its circumference the circumference of a great circle of the sphere, so we find that the two areas are equal, just as was stated.

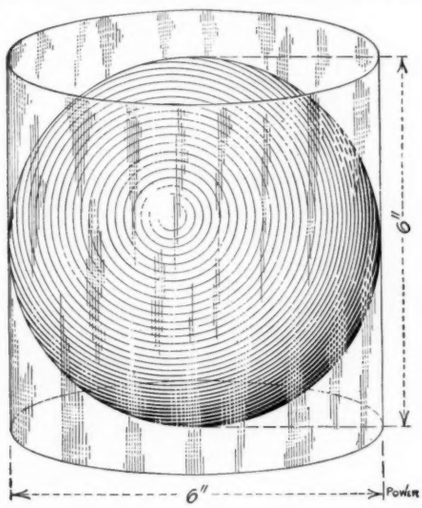


FIG. 3.

Example: What will be the area of a sphere 22 in. in diameter?

The radius will be half the diameter, or 11 in. So, substituting in the formula, we have

$$A = 4 \times 3.1416 \times 11^2 = 1520.53\ in.\ \text{Ans.}$$

If a sphere were cut into several very thin slices, the largest slice, that which would be a section through the center, would be its *great circle*. We see from this that the circumference of a sphere equals the circumference of its great circle.

If a sphere is cut in half, we have two *hemispheres*, which are also *single-base segments* of a sphere. The hemisphere at the bottom and the segment at the top of Fig. 4 are single-base spherical segments. The middle part of Fig. 4 is a *spherical segment of two bases;* this form is also called a *zone* of a sphere. The *altitude* of a spherical segment is the height of the segment or the greatest perpendicular distance between its bases. The radius of the base of a spherical segment is half of the diameter of the base which is a circle; the radius of the upper base of a single-base spherical segment is zero.

Rule: *The surface of a spherical zone, or segment, equals its altitude times the circumference of the great circle of its sphere.*

Or, stated as a formula,

$$A = 2\ \pi\ r\ h$$

where

r = Radius of the sphere;
h = Height or altitude.

The proof of the statement is evident at once from the demonstration given before of the surface of a sphere. Then, each of the unit areas considered was a part of a zone (a $\frac{1}{2\ \pi}$ part) and it was shown that each of these areas equalled one having a base r multiplied by an altitude that is the same as the zone altitude. These areas, therefore, each equalled $r \times h$ and since they were $\frac{1}{2\ \pi}$ parts of zones, a full zone would be $2\ \pi \times r\ h$, as was to be proved.

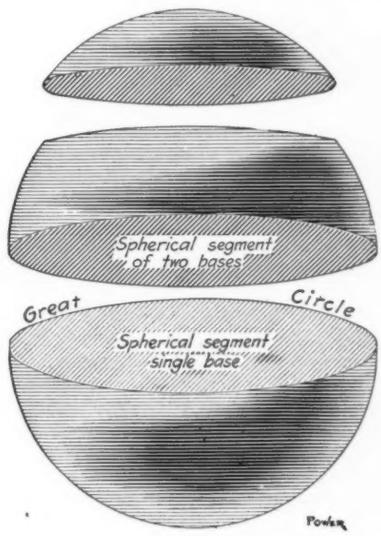


FIG. 4

Example: A sphere with a radius of 4 ft. is cut by two parallel planes, one through the center, the other 2 ft. above the center, forming a zone or spherical segment of two bases. What will be the area of the zone?

The circumference of the great circle of the sphere from which the zone is cut will be the circumference of the base of the zone (because it is a great circle). This times the altitude of the zone gives the area, or

$$2 \times 3.1416 \times 4 \times 2 = 50.2656\ ft.\ \text{Ans.}$$

Rule: *The volume of a sphere equals the area of the surface multiplied by one-third of the radius.* Stated as a formula, we have,

$$V = \tfrac{1}{3}\ Sr$$

where

S = Surface area;
r = Radius.

This is very easily proved from knowledge we already have. It depends only on the fact that the volume of a

pyramid is equal to the area of the base multiplied by one-third of its altitude. Just imagine a sphere made up of a very large number of pyramids, all of the same altitude, with their apexes all at the same point (the center of the sphere). The bases of the pyramids would then form roughly the surface of a sphere, and perfectly so if the pyramids all had small enough bases.

The volume of a group of pyramids, all of the same altitude, would be equal to the sum of their base areas multiplied by one-third of the altitude. And there you are, for that is just what a sphere is, only we call the sum of the bases, the surface, and the altitude, the radius.

Substituting the equation for the surface as previously derived

$$S = 4 \pi r^2$$

in the volume equation gives

$$V = \tfrac{1}{3} \times 4 \pi r^2 \times r = \tfrac{4}{3} \pi r^3 = 4.1888 r^3$$

Or, in terms of diameter instead of radius (r being equal to $\frac{d}{2}$)

$$V = \tfrac{4}{3} \pi \left(\frac{d}{2}\right)^3 = 0.5236\, d^3$$

Example: Find the weight of a cast-iron ball, 15 in. in diameter, cast iron weighing 0.26 lb. per cu.in.

Applying the last formula for volume,

$V = 0.5236 \times 15 \times 15 \times 15 = 1767.15$ *cu.in.*

and the weight will be

$1767.15 \times 0.26 = 459.459$ *lb.* Ans.

ANSWERS TO LAST WEEK'S PROBLEMS

(1) 898.56 lb.

(2) (a) 1304.29 gal.
(b) 4.656 ft., closely 4 ft. 8 in.

(3) 8.89 loads.

(4) The slant height of the housing is 11.045 ft.

As the housing has no flooring and nothing is allowed for waste, 530.16 linear feet will be necessary.

California Engineers Seek State Regulation

The steam engineers in California are taking active steps toward improving their standing by securing state regulation of their work. Recently a meeting was held in the Pacific Building, in San Francisco, which was attended by delegates from 30 organizations of steam engineers for the purpose of considering a proposed state license for the craft.

A special committee appointed to look into the matter submitted a draft of the proposed law, which was approved by all the delegates present. This measure will be submitted to the coming session of the legislature which will meet in Sacramento the early part of this year. It provides for the examination and licensing of all engaged in steam engineering by a board of three examiners, to be appointed by the governor.

A vigorous campaign will be conducted at Sacramento in support of this measure when it is presented for the action of the legislature. Nothing is being left undone by those interested in this movement to secure its early passage. With the assistance that is being solicited of the central labor bodies as well as the employers' associations, there is good reason to believe that the outcome will be successful.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

At this writing, President Taft has become a professor and Professor Wilson the President. All the excited populace is hip-hipping and the enthusiastic press hur-hurrahing; everybody loves his neighbor, the good times are here, and the goose hangs high, all because Bill steps down and out and Woody steps up and in. But, tomorrow! Then begins the tinkle of the anvil chorus. The populace and the press take their respective corners, time is called, the battle is on, and the slugging begins. At least, this has always happened after other presidential elections. In the meantime—"John Henry, if you're goin' to work today, you'd better get up!"

George F. Paul, in the February "Edison Monthly," contends that—

The whale that bolted Jonah down
Was kept awake o' nights
By hearing Jonah's frantic cry,
"Turn on the 'lectric lights!"

Nay, nay, friend Paul, the "shut-down" must have really taken place when—

The whale that bolted Jonah
(Thereby gaining wide renown)
Threw off his "load" as Jonah said:
"You can't keep good men down!"

We will stand for the boozoriums being called "power houses" and their output "shocks" and "third rails," but we'll rear on our hind legs if the lunch counters ever adopt the "2000-volt" snack. They may feed invalids this dose in that gay Paris—a newspaper says so. We refuse to mix our business with our pleasure.

Our government has given the tomato first place in the vegetable kingdom "because it can be prepared in a greater number of ways." We once questioned the preparedness of a luscious, blood-red tomato coming our way, just bursting with enthusiasm and over-development. When our alabaster brow had bisected its line of travel, we changed our mind (and our habiliments). Hail to King Tomato; it's all to the catchup when bottled up!

Of the countless words written in eulogy of the Father of our Country, we like best Artemus Ward's epigram: "G. Washington never slopped over." Which thought impels us to the belief that this Do-it-now thing should give place to the slogan "Never slop over!" Do-it-now has been taken too literally by people who are always doing the wrong thing—and by absconding cashiers.

The United States Supreme Court is asked to decide the question, When is an orange ripe? Having solved this problem, we would ask, When is an egg, and why? We have every respect for a young and tender egg, but once its youth has fled and it evinces strong signs of the decay of old age—well, some court of last resort should come to our assistance.

Surely the foreword page, "Engineers of Tomorrow," in this issue, must bring to mind your boyhood. Those were the days when mother's empty flour barrels disappeared; Dad "cussed" because be could not find one crooked, rusty nail to mend the hencoop, and the family hammer and the bucksaw were left in the yard over night to rust in the dew; the ax got an inch "nick" in it trying to cut a nail; the new bundle of shingles for that leak in the roof, and the laths, were gone; those barrel-hoops for the tomato plants; the parlor-stove pipe, the lantern that illumined the path to the barn, the screwdriver to hang the screen door, the monkey-wrench, the— Why, Jimmy, you and me and the Wilkins boys were building an engine! And it all helped afterward, for Tommy Wilkins is today pulling out the fast freight on the X., Y. & Z.; Hen Wilkins is building real engines, and you and me—well, we're "engineers of today."

Collapse of Fourteen-foot Flume

SYNOPSIS—Shortly after water had filled the pipe the flume collapsed for 1000 ft. of its length. Probable cause, unbalanced air pressure.

On Feb. 18, a new 14-ft. steel flume of the Balleville Hydro-electric Co., located at Balleville, Ohio, which is about three miles from Fremont, partially collapsed for 1000 ft. of its length. The flume, which was laid on the west bank of the Sandusky River, rested on a double row of concrete piers fitted with saddle caps. It was designed to carry the water from the dam to the power house, some 3000 ft. distant, under a head of 30 to 40 ft. The power plant was equipped to generate 6000 kw., which had been contracted for by the Lake Shore Electric Co.

The accompanying drawing shows the design of the joint.

The photographs show what happened to the flume. In Fig. 1, the crosses indicate the limits between which the collapse occurred. The maximum drop was about 6 ft. In Fig. 2, the fishplates have been removed and the breaks in the angles near the joints are evident. Fig. 3 shows how the vertical legs of the angles buckled at the top of the flume.

No data, giving the grades of the flume along its length, are available, but from the photographs it would appear that the run is practically straight with a uniform drop toward the plant. Evidently the cause of the collapse was unbalanced air pressure between the interior

FIG. 1. COLLAPSE OF THE FLUME OCCURRED BETWEEN THE CROSSES

FIG. 2. FISHPLATES REMOVED, SHOWING BREAKS IN STIFFENING ANGLES

Water was turned into the flume for the first time on Feb. 18, and shortly after the flume had filled, the collapse occurred, starting at a point about 250 ft. below the head gate at the dam. Following are some details of construction:

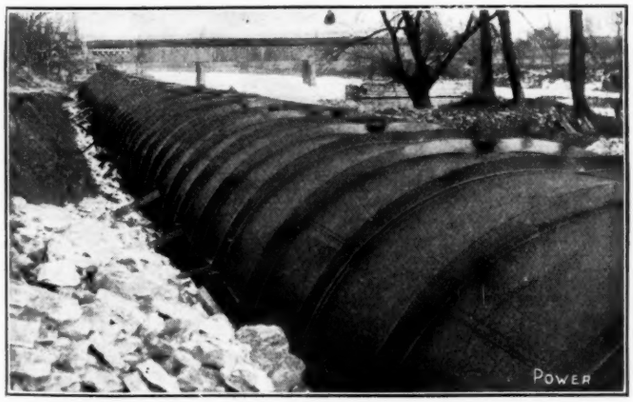


FIG. 3. VERTICAL LEGS OF ANGLES BUCKLED AT TOP OF PIPE

The thickness of the sheet is $\frac{5}{16}$ in., with girth seams 6 ft. 8½ in. apart. The rivets have a diameter of ⅝ in. on 2½-in. pitch. Stiffening angles 6x4x⅜ in., on 7-ft. centers, had been placed around the pipe. These were tied together at the horizontal diameter with fishplates, 15 in. long and drilled for ¾-in. rivets on a 2⅝-in. pitch. and outside of the pipe. With a space in the upper portion of the pipe not filled with water, from some cause not evident from the meager data supplied, a vacuum might be formed so that a difference in pressure could exist. Only a few pounds per square inch would be sufficient

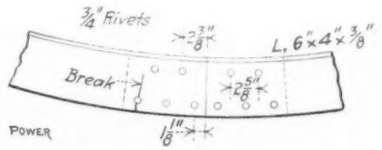


FIG. 4. CONSTRUCTION OF ANGLE JOINT

to cause the accident. Collapse of steel conduits of one-third the diameter, from a difference in air pressure, is not uncommon. As a case in point, might be cited the accidents which occurred in 1911 while testing Bull Run conduit No. 2, then being laid to provide an additional supply of water for Portland, Ore. The line consisted of 24 miles of 52- and 44-in. pipe laid parallel for the most part. In the field, it was common to lay off 4000 to 10,000 ft. of the pipeline, "dead end" both ends of the section and fill it with water. A small pump supplied with steam from a portable boiler raised the pressure to the desired point. In several cases, a rupture of the line occurred from excessive pressure. This allowed the water to discharge at a rapid rate and the upper extremity, in each case, collapsed from external air pressure.

The pipeline at Balleville is 168 in. in diameter and, per lineal inch, would present considerably more surface

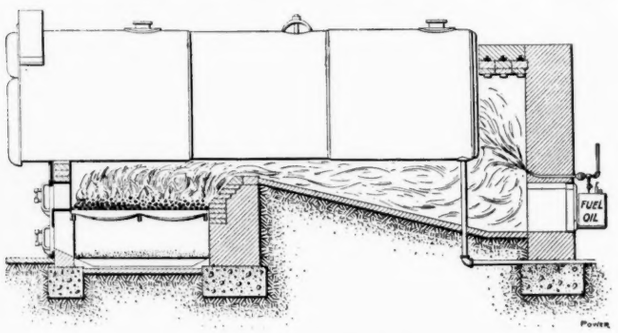
than the Bull Run conduit. It is quite probable that when the pipe was flowing full a leak may have suddenly developed at the low point of the line. For the time being there would be a solid body of water filling the pipe in the vicinity of the leak, while there would be a partial vacuum at the high point of the pipe. At this instant, the excess pressure of the external air would cause the flume to collapse.

An opportunity for the accident would also be presented when the water was shut off at the supply end. Suppose the air vent near the dam had been inadvertently closed, or that its area was not great enough for a rapid emptying of the flume or, perhaps, due to the contour of the pipeline, it was effective only for a short distance along the run, the pressure within the pipe could be less than atmospheric a sufficient amount to cause the collapse.

In either case, a series of air valves opening inward, or standpipes spaced at intervals along the line, would have prevented the trouble. In the construction of the pipeline, a continuous cradle, or at least a filling between supports, rather than the piers and saddles at intervals, would have made a better support for the pipeline and would have tended to prevent leaky joints. It would have, perhaps, been better to stagger the joints on the stiffening angles, and heavier fishplates would also have helped to prevent the collapse.

Rice Regenerator

An apparatus has been invented and developed by John Rice, an engineer of Boston, Mass., which, it is claimed, will facilitate complete combustion in any power boiler by creating secondary combustion. By means of it a vaporized mixture of oxidized fuel oil is atomized and burned in the path of the gases of combustion, reheating, to the point of ignition, any gases that have escaped in imperfect combustion from the boiler furnace.



RICE REGENERATOR

On a return-tubular boiler the atomizing nozzle is inserted through the rear of the setting, as shown in the illustration, to produce the secondary combustion at or about the point of the first turn of the gases from the furnace, and the additional heat, furnished by the burning of the fuel oil introduced and completion of combustion of the furnace gases, is brought directly in contact with the heating surface of the tubes.

It is claimed that complete combustion is obtained and smoke eliminated, as a result of reheating the gases to the point of ignition when supplied with the necessary air, and that the deposits in or on the heating surface of the tubes are materially lessened, insuring a better average transference of heat to the boiler. Also, that the draft is increased and maintained and the necessity of using any artificial-draft apparatus is done away with. The apparatus, it is said, may be used to advantage to meet full-load or overload demands for steam. The cost of operation will depend on the conditions, but an equivalent improvement is declared to result whatever kind of fuel is used.

The device will be marketed by a new company being formed in Boston, to be known as the Rice-Watts Co.

Oil vs Coal for Fuel

In his memorandum to the Executive Committee of the Manchester Steam Users' Association, Chief Engineer C. E. Stromeyer discusses the question of the use of oil instead of coal for fuel. Consideration of the problem was suggested owing to the interests of members being affected by the national coal strike in Great Britain.

It is recalled that about three decades ago an enterprising shipowner adapted the furnaces of the boiler of one of his coasting steamers to burn Scottish shale oil. The economic results were so favorable that others started to burn this oil, but as the Scottish shale oil supply was limited prices rose to a prohibitive figure and soon all the steamers had to revert to coal. Mr. Stromeyer uses this as an illustration to show that if American and Russian oils were suddenly to be largely used instead of coal, a similar condition of things would arise. His conclusion is that the general use of oil is out of the question in countries which are rich in coal, except under exceptional conditions, such as a national coal strike.

Recognizing that coal varies from less than $2.50 for slack near the colliery to well over $5 for good coal in towns, Mr. Stromeyer admits the difficulty in making a comparison of prices, but submits Table 1 giving the relative prices of oil and coal if equal economical results are to be obtained.

TABLE I. RELATIVE PRICES OF COAL AND OIL

Crude oil per ton, dollars	8.75	10.00	11.25	12.50	13.75	15.00
Crude oil per gallon, cents	3.5	4.0	4.5	5.0	5.5	6.0
Good coal per ton, dollars	6.50	7.50	8.50	9.50	10.25	11.25

At briefly stated in a covering letter with the ruling prices for crude oil at say 5c. per gal., the price of coal would have to rise to $9.50 per ton before the two fuels would be equally expensive to burn. The case is different when the oil is not used for raising steam but for generating power in internal combustion engines; then if the price of crude oil be again taken at 5c. per gal. it would be profitable to use this oil should the price of good coal exceed $3.75.

Mr. Stromeyer expresses the view that even if the prices of coal and oil should come into harmony, the latter fuel is not as advantageous as would at first sight appear. He says that with suitable sprayers the thermal efficiency is doubtless relatively high, but at best this will allow of a gain of only about 5 per cent., and against this has to be set the disadvantage that high efficiencies are associated with high furnace temperatures and also with such boiler troubles as bulges, grooves, etc., especially if the boiler water is at all sedimentary or greasy. Oil firing advantages are the ease with which it can be regulated and the absence of ashes and clinker, but oil must be burnt in brick-lined combustion chambers, which suffer from the intense heat and have to be frequently repaired and renewed.

To show that where steam engines can be replaced by internal combustion engines a different economic comparison results, Mr. Stromeyer gives the following particulars:

Roughly stated, a first-class modern steam engine utilizes about 12 per cent. of the available heat in the coal, resulting in say 1.6 to 1.7 lb. of fuel per b.hp.-hr. during a week's work of 55 hr. If the boilers are to be fired by producer gas, for which purpose slack and dust can be used, then each brake horsepower will require about 2 to 2.2 lb. of coal. Internally fired gas and oil engines are approximately twice as efficient as steam engines, which means that they utilize about 25 per cent. of the available heat. Crude oil being 37 per cent. better than good ordinary coal, oil engines should use only about three-eighths of the quantities of coal mentioned above, say about 0.6 lb. per b.hp.-hr. Then, however, as there are no boiler radiation losses over night a material saving results and the oil consumption per week of 55 hr. may be about 0.5 lb. per b.hp.-hr. Petrol and similar internal combustion engines would require about 0.4 lb. per b.hp.-hr. Gas engines have also about the same efficiency as oil engines; but as there is a loss of about 20 per cent. in the producers, if these work day and night, and another loss of quite 10 per cent. if they have to stand idle overnight, the efficiency of gas engines is only about 40 per cent. better than that of first-class steam engines.

Table 2 shows the relation of prices per ton (to secure equal economy) of oil and coal for various engines.

TABLE 2. RELATIVE PRICES OF COAL AND OIL FOR VARIOUS ENGINES

Crude oil for Diesel engine.	$8.75	$10.00	$11.25	$12.50	$13.75	$15.00
Petrol for Diesel engine....	11.00	12.50	14.00	15.50	17.25	18.75
Coal for producer gas engine.....	2.88	3.38	3.75	4.13	4.63	5.00
Coal for gas fired boiler...	2.12	2.38	2.62	3.00	3.25	3.50
Coal for steam engine.....	2.50	3.00	3.38	3.75	4.15	4.50

In further discussion of the problem the appended extract from the memorandum may be of interest. It ought to be profitable to work internal combustion gas engines, for although gas producers can be fed with very cheap fuel, the above list shows a profit even when paying 15 per cent. more than for steam coal. The reason why these engines are not used as much as might be expected, is that they are not self-contained like oil engines, but are hampered with costly and troublesome gas producers. To reduce this nuisance, gas might be produced at central stations and supplied through pipes to gas engines at the works; but that means that factories would have to be clustered together, which is against the present tendency and permits for large pipes would have to be obtained.

One additional reason against gas engines, and it applies equally to all internal combustion engines, is their liability to give trouble. This is due partly to the very high temperatures of the ignited oil or gas mixtures, which result in very serious difficulties, more particularly in large engines; serious troubles are also traceable to the severe and sudden shocks associated with gas and oil explosions. They caused trouble enough in small petrol engines, and are so serious in larger engines that certain dimensions cannot as yet be exceeded, which means that large powers can only be obtained by a large number of cylinders.

No mention has been made of electricity, for it is not a primary power but merely a transmitter of power, which means that steam engines, gas or oil engines or water where this is available, would still have to be used. Electricity has the advantage that it can be transmitted over long distances through small wires, so that if power could be cheaply produced it would be better to convert this into electricity for distribution than to distribute the gas in large mains to the surrounding factories.

However, for different purposes, heat is required in factories, and if one boiler is required it may as well be made large enough to drive the engine or be associated with one or more boilers which can all be worked by one stoker.

Pratt Institute Exhibit of Evening Work

The annual exhibit of the work of the evening classes in Pratt Institute, Brooklyn, was held on Monday evening, Mar. 17, from 8 to 10 o'clock, and was open to the public. The exhibit reflected great credit upon both instructors and students and was most successful. It included the work of both men and women in drawing and design, applied art, applied science, sewing, dressmaking, millinery, household arts and various mechanical trades, and afforded visitors an opportunity not only of viewing the work of the students in the various courses, but also of inspecting both the results and methods as well as the equipment and general facilities of the school for conducting this kind of industrial training.

The School of Science and Technology provides instruction in industrial electricity, technical chemistry, mechanical drawing and machine design, strength of materials, stationary engineering and power-plant machinery, machine work and tool making, carpentry and building, pattern making, sheet-metal work, plumbing and advanced manual training for teachers.

Recovery of Coke from Ashes

The proposition to recover the combustible remaining in coal ashes, which has so frequently attracted attention of economists, is receiving earnest attention in Germany where it is said 150 million tons of coal are burned annually and about one-third of that amount is burned in furnaces from which the ash and cinder would yield 6 to 8 million tons of residual matter containing 2 to 3 million tons of combustible material. A mechanical process for separating the combustible matter from ordinary boiler and household ashes has been designed by Adolph F. Muller.

An experimental plant is said to recover 38 tons of coke ½ to 2 in. in size from 2000 tons of ordinary boiler ashes. Calorific tests have shown that this recovered material, when dry, contains about 84 per cent. combustible matter and has a thermal value of about 6500 B.t.u. per lb. The process consists in first crushing the ashes and then separating the ingredients, by placing them in liquids of different specific gravities. The slag left after the separating process is practically free from any combustible material and is found to be an excellent material for use in the manufacture of concrete blocks.

The inventor of the apparatus is engaged in erecting a commercial plant for recovery of coke and slag in one of the suburbs of Berlin.

NEW PUBLICATIONS

ALTERNATING CURRENT MACHINERY. By William Esty. Published by the American School of Correspondence, Chicago. 1912. Size, 6x10; illustrated; half leather.

The previous editions of this work, as one of the text-books of the American School of Correspondence, have become so well known and so generally used that little need be added, except that the present edition contains some 50 more pages than the former, and the text has been rearranged and partly rewritten to cover the latest practice in alternating-current work. The same method of presentation is employed and the subject is successfully handled without recourse to higher mathematics.

DIESEL ENGINES FOR LAND AND MARINE WORK. By A. P. Chalkley. Published by D. Van Nostrand Co., New York, 1912. Size, 9x5 in.; 226 pages; illustrated; cloth. Price, $3, net.

During the fifteen years that the Diesel engine has been in commercial use, it has formed the topic of many articles in the technical press, and most books on internal-combustion motors have devoted more or less space to the subject; usually, however, in a very general way. The present work is the first attempt at an exclusive and complete treatment of the subject in book form.

Following an introductory chapter by Dr. Diesel, setting forth the scope of the Diesel engine, the author first takes up the general theory of heat engines with special reference to the Diesel type and then explains in an elementary manner the working of this type. Constructive details are next taken up, in which connection the principal makes are described and illustrated.

A particularly instructive chapter is that which deals with the installing and running of Diesel engines. This is followed by a chapter on testing, which contains much useful data on the performance of these engines.

The marine type receives considerable attention and the problem of reversing arrangements is dealt with at some length.

The subject is handled in a simple yet comprehensive manner, and the book should prove a ready reference for engineers interested in Diesel engines.

WATER: ITS PURIFICATION AND USE IN THE INDUSTRIES. By William Wallace Christie. D. Van Nostrand Co., New York City. Cloth 5½x8-in.; 79 illustrations; 3 colored plates. Price, $2.

Much of the material of this book appeared in a series of articles in "Industrial Engineering and Engineering Digest." To this the author prefaced material appropriately introductory to the subject and he has systematically linked together the leading requirements and methods of purification of water in such a manner as to make presentation of the subject sufficiently complete and comprehensive for an owner or engineer to decide upon the methods of purification and type of apparatus most suitable for treatment of water for the leading industrial purposes.

The different methods required for purification are set forth and representative apparatus is illustrated and described in each instance; and although the author refers by illustration to apparatus furnished by different manufacturers, their identity will be apparent only to those who have made a special investigation of the commercial side of the subject.

In the preface it is stated that the description of each manufactured apparatus referred to has had the approval of the maker and all information has been brought down to the present.

Following reference to the sources of waters and the impurities found in water, the author describes in detail what the impurities will do, also the properties of water required in the various industries: for example, concrete, dyeing and bleaching, tanning, ice making, laundries, etc. The laundrymen will appreciate the pages which are given to the saving to be had in soap—from use of water softening apparatus. A number of analyses are given and the results obtained in purifications or treatment. Nearly all of the illustrations, which are 82 in number, including three in color, clearly show the processes referred to. The leading types of water softeners and the peculiarities of the different machines for different purposes are described. After treating cold process softening, the hot process systems are taken up, giving the chemicals used and the results obtained from these systems.

Another chapter gives the results accomplished by water softening in different parts of the country and sufficient notes of the analyses of the water to get some idea of the benefits of treatment. Pressure filters receive attention, different strainers used are illustrated and tables are given of the capacities of the machines. The purification of water by ozone is considered and reference is made to aeration, giving the nozzles used and their capacity, notice is made of methods of purification of water by sterilization and by heat, and by distillation and data given on storage of water, and losses from surface evaporation in different parts of the country.

Another chapter refers to drinking water, the cost of filtration, the results obtained, and the costs of filtration at some of the largest plants. Open gravity filter tanks are illustrated, and tables given of the size and capacity of the various filters. Purification of water for boilers is not specially considered in this book, the field being covered more thoroughly in the author's earlier book, "Boiler Waters, Scale, Corrosion and Foaming"; but in one of the chapters considerable space is devoted to the treatment of water for removing oil carried over by the engine exhaust from water to be used for boiler feeding and other purposes.

Marine practices are given and the cost of pumping water under various conditions have received attention; the author quoting figures of results obtained in different parts of the country gives the cost of pumping water under different heads and by different methods.

The last chapter gives miscellaneous tables and general information useful in hydraulic computations, including a table of chemical symbols, atomic weights, cost of water works, pipe lines, and capacity of tanks and cisterns of various sizes, and definitions of hydraulic units.

The book is of convenient size for reference, and should prove to be of value to power-plant engineers, mill owners and engineering students.

BOOKS RECEIVED

STEAM ENGINEERING. By William R. King. John Wiley & Sons. Cloth; 450 pages; 6¼x9¼ in.; illustrated. Price, $4.

ENGINEERING DIRECTORY, 1913. Crawford Publishing Co., Chicago. Leather; 1552 pages; 4½x6¾ in.; illustrated. Price, $5.

EVOLUTION OF THE INTERNAL COMBUSTION ENGINE. By Edward Butler. J. B. Lippincott Co. Cloth; 237 pages; 6x8¾ in.; illustrated. Price, $3.

ENGINEER'S HAND BOOK ON PATENTS. By William Macomber. Little, Brown & Co., Boston. Leather; 238 pages; 4¾x7¼ in.; illustrated. Price, $2.50.

THE GASOLINE ENGINE ON THE FARM. By Xeno W. Putnam. Norman W. Henley Publishing Co. Cloth; 527 pages; 5½x7½ in.; illustrated. Price, $2.50.

DESIGN AND CONSTRUCTION OF STEAM TURBINES. By Harold Medway Martin. Longmans, Green & Co. Cloth; 372 pages; 7¾x11 in.; illustrated. Price, $8.50.

STEAM BOILERS. By Edward F. Miller. John Wiley & Sons, New York. Second and third edition revised and enlarged. Cloth; 543 pages, 6x9 in.; 228 illustrations; plates; tables; indexed. Price, $4.

Conference of the Society for Electrical Development

The first general meeting of the Society for Electrical Development was held at the Engineering Societies Building, New York, on Mar. 4 and 5 for the purpose of discussing and formulating a definite plan of procedure.

This society represents the coöperative interests of central stations, electrical manufacturers, jobbers, contractors and dealers, the purpose being to promote these industries through a more extensive use of electricity. Architects and representatives of the press were also invited to join the movement.

President H. L. Doherty, in his opening address, spoke of the aims of the society and said that $100,000 had already been subscribed, but that it was hoped to raise at least $200,000 a year to carry on the work. A large sum would be expended in publicity for which purpose a publicity bureau of the society would be established. One of the chief duties of this bureau would be to keep the public informed of the great work that is being done in the application of electricity to various industries. In his opinion great opportunities lie ahead of the central station, one of these being the use of electricity on the farm. Speaking as a representative of large corporations he believed that the present sertiment toward the regulation of "big business" would be harmful.

James M. Wakeman, general manager of the society, next spoke of its aims and poiated out the need for coöperation in the commercial side of electricity. He also dwelt to some

length upon the publicity idea and also suggested that the society have a staff of trained solicitors which could be placed at the service of the smaller electric companies.

Frank H. Gale, of the General Electric Co., then read a paper on "The News Value of Electricity." He pointed out that there is an abundance of good material which would make interesting reading for the public, but that this must be got up for the benefit of the reader and not from the standpoint of the advertiser. He also urged frankness and publicity upon the part of public service corporations.

A paper on "Electricity and the Architect," by F. E. Wallis, was next read and discussed. This was followed by an address by Dr. Talcott Williams, of the School of Journalism of Columbia University. The speaker referred chiefly to the work that is now being done at Columbia toward preparing students for a journalistic career and said that a very large part of the course was devoted to the fundamentals of physics and chemistry so that the student would be able to comprehend to a cerain extent such technical matter as he might later be called upon to report.

The next speaker was T. C. Martin who, speaking on behalf of the National Electric Light Association, told of that organization's attitude toward the new society, the two having many interests in common. The central station industry, said Mr. Martin, is now doubling itself every five years and anything that the Society of Electrical Development can do to make the industry double at a more rapid rate would be of mutual interest.

J. C. McQuiston, of the Westinghouse Electric & Manufacturing Co., next read a paper on "Efficiency of Local Advertising." He referred to various forms of "display" advertising and called attention to the moving-picture machines as an excellent means of arousing the public's interest in electrical applications.

Other papers read at the session were "The Sales End," by James H. Collins; "Merchandizing Coöperation," by W. E. Robertson, of the Robertson-Cataract Co., and "An Electrical Advertising Campaign," by W. D. McJunkin, of Chicago. All the papers were freely discussed.

The conference ended with a banquet at Delmonico's on the evening of Mar. 5.

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Chief Engineers Club of Detroit

A new engineering society, the Chief Engineers Club of Detroit, has been formed in that city, composed only of engineers holding a first-class city license and employing one or more licensed assistant engineers. It has on its roll most of the progressive engineers running the larger plants. The chief boiler inspector of Detroit is a member by invitation.

The club has as its object the cultivation of good-fellowship among the local chief engineers, by lectures and discussion, to increase the efficiency of its members. It will meet every month in the Wayne County Bank Building.

The officers for the ensuing year are: President, Charles Koehler, Murphy Power Co.; vice-president, Charles Mery, Fairview Pumping Station; recording secretary, Harry E. Page, Hotel St. Claire; financial secretary, Edward Hall, Public Lighting Plant; treasurer, Alexander Kothe, U. S. Frumentum Co.; marshal, Charles Gelhaar, Voigt Brewing Co.; alternate marshal, Harry Stummell, Kling Brewing Co.; chairman of entertainment committee, Joseph H. Roberts, Parke-Davis Co. Charles A. Ellis, of the Chamber of Commerce Bldg., was unanimously elected to fill the office of first past-president.

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The Glenlyon Economizer Explosion

Since the account of the economizer explosion at the Glenlyon Dye Works, Saylesville, R. I., was printed in the issue of Jan. 28, a thorough investigation has been made, but without any more definite findings as to the cause. It has, however, established that the economizer was not inherently at fault, and, in justice to the manufacturer, the following letter it received from the dye works is published:

> In reference to the explosion at our works, which occurred on the 14th of January last, we regret to say that careful and thorough investigation has failed to establish the exact cause.
>
> The explosion apparently occurred in one economizer, which was temporarily out of service for slight repairs, and we think that in some way sufficient water made its way into this economizer to create the pressure which caused the explosion.
>
> We could locate no structural defect in the economizer or weakness in the castings, and feel that if we should have further use for apparatus of this kind to utilize waste heat in chimney flue, we would not hesitate to order a Green economizer for the purpose.

$1,000,000 Steam Power Plant

Announcement is made by C. E. James, of the Chattanooga & Tennessee Power Co., says the "Tradesman," that it will begin at once the construction of a $1,000,000 steam-power plant. The new plant will be operated in connection with the $8,000,000 plant now being erected at Hale's bar on the Tennessee River.

The capacity of the plant is to be 20,000 or 25,000 hp. The purpose is to guarantee to the Chattanooga & Tennessee River Power Co. the maximum capacity of its Hale's bar plant at all seasons of the year and all stages of the river. Without the steam power the expenditure of $8,000,000 at the lock and dam would be reduced to less than half at certain stages of the river, but when the extra $1,000,000 is expended, full returns on the entire investment is guaranteed for each hour of the entire year.

SOCIETY NOTES

On Thursday evening, Mar. 6, Prof. Charles M. Allen lectured on "Gasoline, Its Uses and Abuses," before the Engineers Club, of Boston. The subject as treated created much general interest. Prof. Allen gave demonstrations of the explosive and non-explosive qualities of various mixtures. After the lecture refreshments were served.

The combined N. A. S. E. associations, Manhattan and Bronx, will hold their annual banquet on Thursday evening, Mar. 27, at the Broadway Central Hotel, 673 Broadway, New York City. Good speakers and entertainers are promised and the ladies are invited. Tables may be reserved for parties by applying to the chairman. Tickets may be secured from Samuel I. Schaff, Fred G. Jolley, William M. Logan, Harry Marks and Fred Felderman, the committee.

Arrangements have been made to hold the next convention of the Association of Edison Illuminating Companies at the Otesaga Hotel, Cooperstown, N. Y., Sept. 8 to 11. The Otesaga is charmingly situated on Otsego Lake, in the midst of the hilly country immortalized by J. Fenimore Cooper in his Leatherstocking Tales, and offers facilities of a most attractive nature for the convention. Special arrangements are being made for through railroad service, and the attention of members is directed to the accessibility of this resort by automobile through the Catskill mountains. Details of transportation and automobile maps will be included in the convention circular to be issued when the program has been assembled. President Arthur Williams states that suggestions concerning subjects for papers, or upon other matters which may add to the value of the meeting, will be greatly appreciated.

PERSONALS

Charles P. Steinmetz, past-president, American Institute of Electrical Engineers, consulting engineer of the General Electric Co., Schenectady, N. Y., has been awarded an Elliott Cresson Gold Medal of the Franklin Institute, of Philadelphia, "for successful application of analytical methods to the solution of problems of the first practical importance in the field of electrical engineering."

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The annual meeting of the stockholders of the Goulds Manufacturing Co. was held at Seneca Falls, N. Y., Feb. 24. No change was made in the board of directors and the following officers were reëlected: President, N. J. Gould; vice-presidents, D. V. Colby, W. D. Pomeroy, W. E. Davis, W. E. Dickey; secretary, H. S. Fredenburg; treasurer, B. R. Wells; assistant treasurer, E. W. Medden.

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A bill has been laid before the Prussian Diet for the development of water power on the upper waters of the Weser. It provides for an expenditure of $2,142,000, of which it is proposed to spend immediately only $1,190,000 on the erection of power stations at Hemfurt and Helminghausen; the remainder will subsequently be spent on the construction of a power station at Munden. It is estimated that the three stations can produce 41,000,000 kw.-hr. annually.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Amherst Power Co. has purchased the plant and property of the South Hadley Falls Power Co., South Hadley Falls, Mass. The new owners will construct a substation and install new equipment in the plant. Philip Cabot, Boston, Mass., is president.

Bids will soon be received by W. S. Pierce, commanding colonel of the U. S. armory at Springfield, Mass., for the enlargement of the boiler house and the installation of two new boilers in the armory.

The Webster & Southbridge Gas & Electric Co., Webster, Mass., will install new boilers and a new steam turbine to double the capacity of its plant. H. S. Shaw is superintendent.

The trustees of the Webster State Hospital, Webster, Mass., has asked for an appropriation of $70,000, for the installation of a new power plant. John L. Coffin, Northboro, Mass., is chairman.

Plans are being considered by the board of water commissioners of Black River, N. Y., for the installation of a new water-works system. Charles L. Seybold is president of the board.

The Hewitt Rubber Co. is having plans prepared for the installation of a power plant in connection with its establishment at Kensington Ave. and the New York Central R.R. Belt Line, Buffalo, N. Y.

Plans are being prepared for the construction of a boiler house in connection with the plant of the Augustine Rotary Engine Co., at Elmwood Ave. and the Erie R.R., Buffalo, N. Y.

Sackett & Parke, architects, Syracuse, N. Y., are preparing plans for the construction of a power plant for the Volney Paper Co., at Fulton, N. Y.

The proposition to issue $20,000 in bonds for the improvement of the municipal elecrtic-light plant at Ilion, N. Y., is under consideration.

The Syracuse Crucible Steel Co. of America is considering plans for the construction of a boiler house and transformer station in connection with its new steel plant which it is erecting near Halcomb mills, Syracuse, N. Y. Specifications are on file at the office of G. M. Black, general superintendent, Oliver Bldg., Pittsburgh, Penn.

The Public Service Co., Newark, N. J., will make extensions and improvements to its Plank Road electric substation, to cost about $3000. Farley Osgood, Newark, is general superintendent.

The citizens of Trenton, N. J., are considering the proposition to construct an electric-light plant to supply electricity for lighting streets and public buildings. George La Barre is city commissioner.

The city council of Reading, Penn., has appointed a committee to investigate the feasibility of installing a municipal electric-light plant.

SOUTHERN STATES

The Richmond & Henrico R.R. Co. is preparing plans for the construction of a power plant at Richmond, Va., to cost approximately $35,000. C. Simd-Bailey, Richmond, is general manager and chief engineer.

A franchise has been granted to the Williston Mfg. Co., to construct and operate an electric-light plant at Williston, Fla.

The city council of Elizabethtown, Ky., has decided to install a water-works system and filtration plant.

Bids will be received by the board of public works, until Apr. 2, for the construction of a water-works system at Madisonville, Ky. W. J. Dublin is secretary of the board.

The Kentucky Utilities Co., of Lexington, Ky., has purchased the power plant of the Middleboro Electric Light Co., Midleboro, Ky., and is planning the installation of new equipment in the plant.

Plans are being prepared by the Kentucky Southwestern Electric Ry. Co. for the construction of a power plant at Paducah, Ky., to supply electricity for its proposed 55-mile electric railway.

CENTRAL STATES

The Citizens' Gas Co., Indianapolis, Ind., has been granted permission to expand $12,972, for the improvement of its plant. Two 300-hp. boilers will be installed.

The Indianapolis Light & Heat Co., Indianapolis, Ind., is considering plans for the installation of new equipment in its power plant.

The city council of Bloomingdale, Mich., has granted a franchise to M. C. Hawk to construct and operate an electirc-light plant at Bloomingdale.

An appropriation of 119,500 has been asked by the public lighting commission of Detroit, Mich., for the installation of new equipment in the municipal electric-light plant.

The ciy council of Hastings, Mich., is considering the proposition to issue $90,000 in bonds for the construction of a municipal electric-light plant.

The city council of Marshall, Mich., has authorized an expenditure of $1250, for the improvement of the municipal electric-light plant.

Plans are being prepared by J. Rollin Gray, engineer, Chicago, Ill., for the installation of a water-works system at Carpentersville, Ill. Estimated cost, $30,000. M. D. Baldwin is city clerk.

The construction of an electric-light plant at Decatur, Ill., is contemplated by Frank L. Suffern and associates.

The citizens of Jacksonville, Ill., will hold an election on Apr. 15, to vote on the proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant. Joseph F. Brennan is commissioner of public property.

The citizens of Nokomis, Ill., are considering the proposition to install an electric-light plant.

The Central Illinois Public Service Co., of Mattoon, Ill., is making preliminary arrangements for the construction of an electric-light plant at Perry, Ill.

The village board has granted a franchise to F. T. Morrison, of Dixon, Ill., to construct and operate an electric-light plant at Warren, Ill.

The proposition to issue $15,000 in bonds for the construction of a municipal water-works system at Palmyra, Wis., is under consideration. L. F. Agen is city clerk.

WEST OF THE MISSISSIPPI

Plans are being considered by the city council of Fontanelle, Iowa, for the construction of a municipal electric-light plant to cost $7500.

Bonds for $12,000 have been voted for the improvement of the water-works system at Lake City, Iowa. A. O. Anderson is engineer.

The citizens of Cedar Falls, Iowa, are considering the proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant.

Preliminary arrangements are being made at Early, Iowa, for the construction of an electric-light plant.

The construction of an electric-light plant at Ossian, Iowa, is under consideration. Estimated cost, $8000.

The proposition to install an electric-light plant at Grove City, Minn., is under consideration.

The Central Minnesota Electric & Power Co. is preparing plans for the construction of an electric-light plant at Waverly, Minn.

The construction of an electric-light plant is included among the improvements planned by the citizens of Cimarron, Kan.

The citizens of Augusta, Kan., voted to install a municipal electric-light plant at a recent election. J. R. Switzer is city engineer.

Bonds to the amount of $6000 has been voted for the purpose of constructing a municipal electric-light plant at Blue Mound, Kan. E. T. Archer & Co., Kansas City, Mo., are engineers-in-charge.

Bids are being received by the city of Canton, Kan., for the construction of a new electric-light plant.

The construction of an electric-light plant at Douglass, Kan., is under consideration. Local business men are interested in teh project.

The installation of a new generator in the municipal electric-light plant at Topeka, Kan., to cost $3000, is under consideration.

Bonds to the amount of $20,000 were recently voted for the construction of a municipal electric-light plant at Turon, Kan.

Plans are being considered by the city council of Jamestown, N. D., for the installation of an electric-light plant.

The construction of an electric-light plant at Mohall, N. D., is under consideration.

The organization of a company at Poplar, Mont., to construct and operate an electric-light plant, is being agitated. Estimated cost, $3000.

Albert C. Moore, of Joplin, Mo., has submitted a proposition to the city council of Springdale, Ark., to install an electric-light plant and water-works system.

The city council of Ellensburg, Wash., is considering plans for the improvement of the municipal electric-light plant. The installation of additional equipment is included.

The Elma Light & Power Co. has been granted a franchise to construct and operate an electric-light plant at Elma, Wash.

The citizens of Friday Harbor, Wash., are considering a bond issue for $14,000 for the installation of a municipal water-works system.

The Bryant Lumber Co. will build a new boiler house in connection with its plant at 3200 Fremont Ave., Seattle, Wash.

The capacity of the power plant of the Pacific Light & Power Co. at Wapato, Wash., will be increased by 5000 hp. D. F. McGee is chief engineer.

It is reported that bonds to the amount of $20,000 have been voted for the installation of a water-works system at Milwaukee, Ore. D. P. Matthews is village recorder.

The power plant of the Prairie Light, Power & Milling Co., Prairie City, Ore., was recently destroyed by fire. Estimated loss, $20,000. R. C. Reese is interested.

Extensive improvements to the municipal electric-light plant at Alameda, Calif., including the installation of additional equipment, are being considered. Joseph B. Kahn is superintendent of the plant.

Plans are being prepared for the construction of an electric-light plant atOreana (Lovelocks post-office), Nev.

The plant of the Elsinore Electric Light & Power Co., Elsinore, Calif., has been purchased by the Southern Sierras Power Co., San Bernardino, Calif. The new owners are planning extensive additions and improvements to the property.

The Chanslor-Canfield Midway Oil Co. has prepared plans for the construction of two boiler houses in connection with its establishment at Fellows, Calif. Estimated cost, $5000.

The Atchison, Topeka & Santa Fé R.R. Co. is planning to enlarge the capacity of its precooling and ice-making plant at San Bernardino, Calif. Estimated cost, $250,000. G. W. Harris, Los Angeles, Calif., is chief engineer.

The Producers' Mutual Dairy Association will erect a building at 12th and K Sts., San Diego, Calif., to be equipped with machinery for an ice and cold-storage plant. Estimated cost of equipment, $20,000.

The city engineer of Santa Monica, Calif., is preparing plans for the installation of a new municipal water-works system. Estimated cost, $76,000.